THE EMERGING SOUTH AFRICAN NATIONAL HEALTH INFORMATION SYSTEM

Strategies, Approaches and Experiences

Editors: A. Botha, M.E. Herselman and P. Rousseau

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Department:
Health
REPUBLIC OF SOUTH AFRICA

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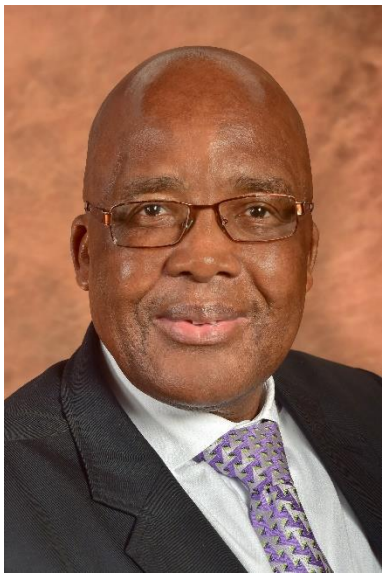

Foreward by Minister of Health

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DR. P. A. MOTSOALEDI, MP
MINISTER OF HEALTH

Foreward from CSIR

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DR. X. Y. SOMEONE
POSITION

Acknowledgements

The editors would like to take the opportunity to thank all the contributors to each chapter for their diligence and commitment to crafting their papers and improving them based on the double-blind review feedback process, as this collaborative process is fundamental in transforming initial ideas into high-quality, impactful scholarship that can meaningfully advance research on the South African National Health Information System.

This collective endeavour not only enhances the overall quality of the work but also underscores the invaluable role that each contributor plays in the scholarship presented, as their diverse perspectives and expertise enrich the research outcomes, leading to more coherent and impactful results.

We would also like to thank the South African National Department of Health for supporting and initiating this publication and encouraging provincial departments to contribute toward this endeavour.

We also acknowledge the Next Generation Enterprises and Institutions Cluster for supporting, editing and contributing to this research project. The insights and experiences shared by researchers across different disciplines can enrich the research process by introducing new theoretical frameworks, methodological approaches, and practical considerations that may have been overlooked from a single disciplinary perspective.

Additionally, we acknowledge the essential contributions of the peer reviewers whose constructive feedback was instrumental in refining the manuscripts, ultimately leading to a more rigorous and reliable collection of studies for our readership.

Furthermore, it is essential to recognise the efforts of the editorial team, whose diligent coordination and support throughout the publishing process have ensured the seamless integration of the contributors' works into a cohesive and well-structured volume, reflecting the highest standards of academic integrity and excellence.

We also extend our appreciation to the additional individuals and organizations that provided technical assistance and resources, as their contributions were vital for achieving our shared goal of producing a reliable collection of research that can advance knowledge in the field.

By fostering an environment where academic collaboration and knowledge sharing are prioritised, the editors hope this publication will serve as a model for future endeavours, inspiring and guiding researchers to collectively advance the South African National Health Information System and contribute to the ongoing academic discourse.

This publication underscores the collaborative nature of academic research, where the synthesis of diverse intellectual contributions from a range of experts, including authors, reviewers, and supporting personnel, leads to significant advancements and breakthroughs that enhance the overall quality and impact of the work.

We extend our sincere gratitude to the following reviewers for their invaluable insights and dedication to upholding the quality of this work: Prof Flip Schutte, Prof Retha de la Harpe, Prof Tembisa Ngqondi, Dr Bertie Buitendag, Prof Maria Toivanen, Prof Judy van Biljon, Dr Isabel Meyer, Prof SS Grobbelaar, Dr Eoudia Vermeulen, Prof Gloria Iyawa, Prof Petra Bester, Dr Monelo Nxozi, Dr Rosalyn Adetunji, Prof Eugene van Wyk, Dr Jaco du Toit, Prof Pfano Mashau, Prof Marita Turpin, Prof Darelle van Greunen, Dr Kevin Naicker, Dr Samwel Mwapele, Dr Richard Shoniwa, Dr GG Niguse, Prof Hans Ackermans, Prof Chris Seebregts, Prof Manoj Thomas, Prof Boada Pablo, Prof Li Yan, Dr Mario Marais, Prof Silvia Masiero, Prof Amado Espinosa, Prof Luidmila Pankratyeva, and Prof Anna Bon.

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Introduction

In the ever-evolving landscape of healthcare, where innovation and adaptation are paramount, the chapters that follow offer a remarkable journey through the intricacies of South Africa's digital health evolution. This compilation encapsulates a rich tapestry of approaches, strategies, and experiences that illuminate the path toward a more efficient and patient-centred healthcare system.

From the development of data managers to the implementation of electronic prescribing systems, these chapters underscore the critical role that technology plays in shaping the future of healthcare. Each chapter, in its own unique way, contributes to the broader goal of improving patient outcomes, fostering resilience, and harnessing the power of data.

We are profoundly grateful to the authors who have shared their insights, lessons, and recommendations. These narratives reflect the dedication and ingenuity of those working tirelessly to advance the South African healthcare landscape. As we delve into the pages ahead, let us not only appreciate the progress achieved but also draw inspiration for the journey that lies ahead.

In today's complex world, where healthcare is at the forefront of our collective consciousness, these chapters offer a glimpse into the future—a future where access to quality care knows no boundaries, where data-driven decisions enhance patient well-being, and where digital innovation fuels progress.

Thank you for embarking on this enlightening exploration of South Africa's digital health transformation. The stories within these chapters serve as a testament to the collaborative spirit and unwavering commitment to the betterment of healthcare for all.

As we turn the pages, let us remember that these are not just words on paper but a roadmap to a brighter, healthier future. May this compilation inspire and guide us as we collectively navigate the complex yet promising terrain of digital health in South Africa and beyond.

With gratitude and anticipation,

CHIEF DIRECTOR: HEALTH SYSTEMS - DIGITAL INFORMATION
NATIONAL DEPARTMENT OF HEALTH

Section A: Strategies

Dr. P. Rousseau

The success of any healthcare transformation relies on well-crafted strategies that align with overarching goals. In this category, we explore the strategic blueprints that underpin the South African Digital Health Strategy. These chapters dissect the strategies, policies, and directives that guide the nation's journey towards a digitally empowered healthcare landscape. From building digital health ecosystems to leveraging technology for epidemiological surveillance, these chapters unveil the strategic threads that are knitting together South Africa's healthcare future.

Chapter 1: Towards National Health Information System Use Cases

Botha, A.[1] and Herselman, M.[1]

[1]Next Generation Enterprises and Institutions Cluster (NGEI), CSIR, Pretoria

Purpose: *The study aims to identify and prioritise National Interoperability Use Cases aligned with national health objectives to guide the development of a robust National Health Information System (NHIS). The primary objective is to produce a list of National Interoperability Use Cases, categorised by their importance and feasibility, to inform the development of a shared NHIS. The study aims to align these use cases with national health priorities, ensuring they are practical, interoperable, and adaptable to evolving technological environments.*

Study Design: *A modified Delphi methodology was employed, engaging stakeholders across various health sectors through iterative rounds of engagement and feedback. The study employed clustering methodologies, specifically K-means clustering, to categorise the use cases by priority. Additionally, the Kemeny-Young Method was used for ranking, and consensus among stakeholders was measured using Kendall's W for validation.*

Findings: *The study generated a prioritised list of use cases divided into four clusters based on their "Must have," "Should have," and "Could have" attributes. The clustering provided clarity on foundational and optional use cases, allowing for the strategic planning of the NHIS. The findings suggest a strong consensus on the importance of use cases related to Electronic Health Records, alignment between health information systems, and emergency responses.*

Value: *The findings contribute to the ongoing efforts to develop an interoperable NHIS. While the research emphasises a systematic approach to use case prioritisation, it acknowledges the need for adaptability to emerging health technologies and continual reassessment. The framework presented aims to facilitate stakeholder collaboration and informed decision-making in developing the NHIS.*

Keywords: *National Health Information System, Interoperability Use Cases, Delphi Methodology, K-means Clustering, Health Information Technology, System Integration, Health Policy, Electronic Health Records, Stakeholder Engagement.*

1.1 Introduction and Background

The first step in implementing the Health Normative Standards Framework (HNSF, 2021) is identifying and formulating National Interoperability Use Cases rooted in national health priorities. These use cases guide the development of Interoperability Specifications and help identify gaps to be addressed in future HNSF iterations.

The National Interoperability Use Cases, Business Instances, Implementation Outline, Technical Use Cases, and the resulting integration profiles' understanding, and relationships are illustrated below Fig 1-1). National Interoperability Use Cases are formulated based on national health priorities and define the high-level requirements for interoperability (Bourquard et al., 2015; Bourquard et al., 2017; Park et al., 2021).

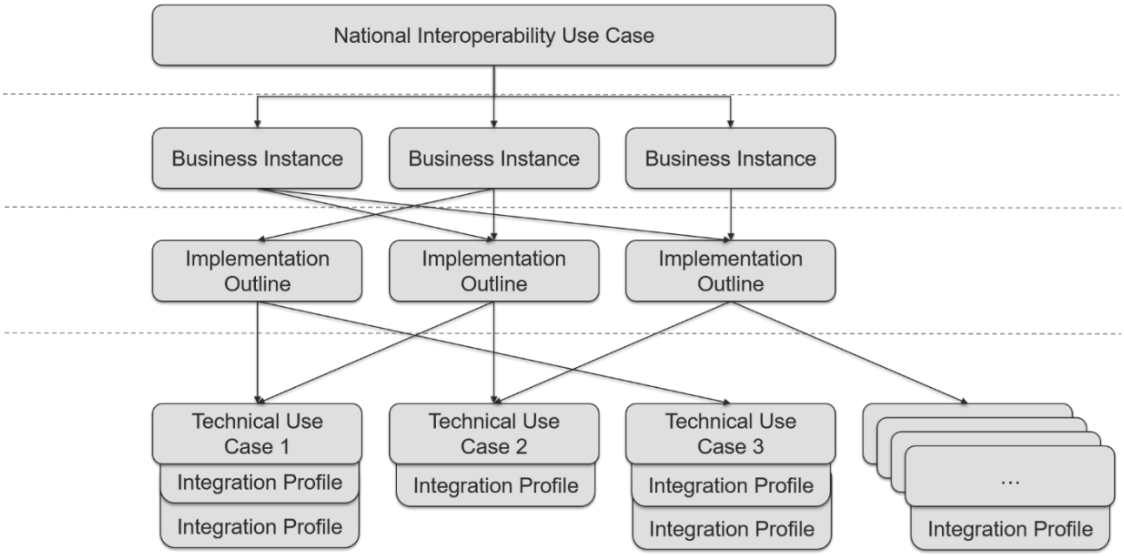

Figure 1-1: Generic example of the relationship between various interoperability concepts (Adapted from Bourquard et al., 2015; Bourquard et al., 2017; Park et al., 2021)

- National Interoperability Use Case: National Interoperability is seen as an overall description of a need for information sharing within and across healthcare organisations that use health information technology, often linked to health objectives. Users write it in a natural language and may include several healthcare-related Business Instances. The Health Information System (HIS users) develops a National Interoperability Use Case, and the target audience is HIS decision-makers (Torab-Miandoab et al., 2023). National Interoperability Use Cases are specific use cases within a fully interoperable environment in South Africa and should be prioritised to meet the needs of the South African health domain.
- Business Instance: A Business Instance describes a specific example of HIS used for information sharing within the Use Case. Several Business Instances may derive

from a single Use Case (ITI Technical Committee, 2022). Business Instances depict business actors (humans) and technical actors (systems), the scope and workflow of healthcare professionals' tasks and associated data flow. It is written in a natural language and may include several Implementation Outlines (Bourquard, Orlova & Parisot, 2017; Proctor, 2024). The users of the HIS develop a business instance, and the target audience is healthcare professionals.

- Implementation Outline: An Implementation Outline describes a subset of workflow steps and data requirements within specific Business Instances from the business actors' perspectives and specific transactions of technical actors (systems) to support workflow steps and data requirements (Proctor, 2024). Examples of transactions include send–receive data, data queries, and others. It is written in a natural language and may contain several technical use cases for the selected transaction. It is described in Volume 1 of the IHE profile (ITI Technical Committee, 2022; Bourquard et al., 2017). HIS users and IT specialists develop implementation Outlines, and the target audience is project managers, system architects, and implementers.
- Technical Use Cases: Technical use cases describe a need for a specific transaction between technical actors (systems, IHE actors) that supports the Implementation Outline (Proctor, 2024). They are written in technical language and may include several implementation options enabled by individual standards selected for the transaction. They are described in Volume 2 of the IHE Technical Framework Documents. IT specialists develop technical use cases; the target audience is system architects and implementers (ITI Technical Committee, 2022).

In summary, selecting National Interoperability Use Cases would enable the selection of profiles and underlying standards and verifying and identifying gaps in the standards framework. This would lead to selecting additional relevant standards and value sets through a localisation process.

To frame the identification of these National High-Level needs, it is proposed that a Delphi technique is applied to open a domain conversation and provide a more focused selection of concerns for consideration.

1.2 Methodology: Delphi Study

The Delphi technique is a quantitative methodology that will be used to elicit domain consensus. Opinions from domain stakeholders will be canvassed through an iterative process of engagement.

After each engagement iteration, the domain responses will be summarised and then redistributed for discussion in the next iteration. A domain consensus is reached through a process of convergence involving identifying common trends and inspecting outliers (Williams & Webb, 1994).

There is considerable literature that supports the use of Delphi studies and its adaptions in the health domain. The online modified Delphi method for engaging stakeholders and their representatives through a three- or four-round engagement process will be used to suggest a prioritised list of National Interoperability Use Cases (Khodyakov et al., 2020).

Under round 0 of the Delphi study, ideas are generated using a case-driven approach to document user needs (Bruegge & Du Toit, 2009). Feedback on possible use cases was captured and thematic coding was applied using Atlas.ti software.

In round 1, verification was applied to verify the use cases and hypotheses. The z-test was applied to assess the relevance of each use case and determine whether the proportion of respondents who viewed each use case as important was significantly greater than 50%. This was followed by p-value calculations for each item, representing the probability of obtaining a z-score as extreme as the observed one if the null hypothesis were true.

During round 2 of the Delphi method, the study employed clustering methodologies, specifically K-means clustering, to categorise the use cases by priority. According to Kavlakoglu & Winland (2024), K-means clustering is an unsupervised learning algorithm used for data clustering, which groups unlabelled data points into groups or clusters.

During round 3 of the Delphi method, the Kemeny–Young method was used for ranking. This method is an electoral system that uses preferential ballots and pairwise comparison counts to identify the most popular choices in an election (Rico, Vela & Diaz, 2023). It is a Condorcet method because if there is a Condorcet winner, it will always be ranked as the most popular choice. This method assigns a score for each possible sequence, where each sequence considers which choice might be most popular, which choice might be second-most popular, which choice might be third-most popular, and so on, which choice might be least popular (Rico et al., 2023). The sequence that has the highest score is the winning sequence, and the first choice in the winning sequence is the most popular.

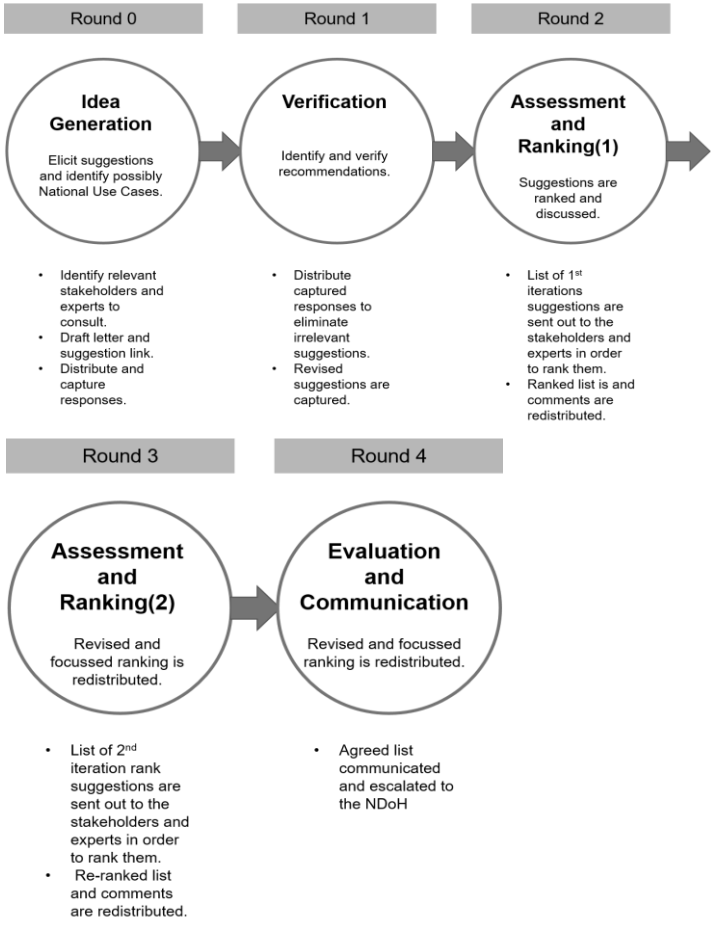

Figure 1-2: Delphi Study applied to this study (Adapted from Okoli & Pawlowski, 2004)

In round 4, consensus among stakeholders was measured using Kendall's W for validation. During this round, evaluation and communication validate, contextualise, and refine the prioritised use cases identified in previous rounds. The consistency of stakeholder rankings was measured using Kendall's W, a coefficient of concordance that reflects the level of agreement among participants (Rico et al., 2023; Emerson, 2023). This is followed by an expert review with purposefully selected domain experts, whose feedback will refine and contextualise the use cases. The figure above describes the process followed using the Delphi method. Each round in this process is then explained in further detail. The Delphi method was supplemented by statistics in each round.

1.3 Round 0: Idea Generation

National Interoperability Use Cases are thus seen as overarching descriptions of the need for information sharing within and between healthcare organisations using Health Information Technology (HIT). These use cases should align with National Health Objectives and are written

by users in natural language, making them accessible and easy to understand. National Use Cases can encompass multiple interoperability use cases, addressing the broader needs of the healthcare system. Candidate National Use Cases, generated through ideation processes, are positioned for further evaluation as potential National Use Cases. The invitation and outline are available as Appendix A

The Idea generation iteration was intended to elicit suggestions around possible National Use Cases (Kim et al., 2018). A use case-driven approach is the foundational methodology for documenting user needs (Bruegge & Dutoit, 2009).

- Various individuals and organisations were targeted to identify and incorporate as many stakeholders as possible. The process is ongoing for the duration of the Delphi study, and submissions were directed to the researcher.
- A draft letter was prepared and submitted to the NDoH. After receiving confirmation, the invitations were sent out, and the feedback was captured.
- A total of 65 engagements were recorded.
- All of the suggestions submitted are considered Candidate National Use Cases. No value judgement is attached to each suggestion's feasibility or importance. In cases where the use case was implicit, the inferred Use Case that would frame the activity was implied and recorded.
- Atlas.ti was used to assist in Thematic Coding. Once saturation was reached, no more significantly novel Candidate National Use Cases were identified.

The following is synthesised as the identified Candidate National Use Cases:

Table 1-1: Candidate Use Cases

Candidate National Use Cases
Access to Medication List
Alerts and notifications
Alignment between the DHIS2, the Financial Management system, and PERSAL
Analytics through actionable data for Population Health Management
Billing
Bio surveillance
Care Plan Management
Clinical Coding
Clinical Research and Trial Management
Compliance testing of applications
Consent-based data access
Consultation and transfer of care
Curation and validation of terminologies and value set
Disease Surveillance
Electronic Discharge Summary.
Electronic Health Record
Emergency response

Candidate National Use Cases
ePrescribing and Medication Management
Healthcare provider lookup and validation
Health management information system (HMIS) for HIV/TB and other nationally prioritised health conditions
Immunisation information management
Laboratory requests, result reporting and workflow.
Maternal and childcare management
Medication management
Mobile services
Mobility of Patient Records
Multi-disciplinary consultations
Manicures
National Aggregate Reporting
Operation Management and supply logistics
Patient identity lookup and validation
Quality assessment and reporting
Radiology reporting and results sharing
Referral and discharge reporting
Remote Monitoring
Secure Messaging
Transition of Care
Validation of Facility data

While challenges existed in engaging a balanced respondent pool, the response rate achieved was commendable, providing a solid basis for further analysis. The primary goal moving forward was to systematically organise and prioritise use cases based on their perceived importance and feasibility, which was accomplished through K-means clustering.

1.4 Round 1: Verification

The Verification iteration is intended to verify suggested National Use Cases. The outcome is envisaged to eliminate irrelevant suggestions, revise and synthesise the suggestions, and possibly elicit additional suggestions.

The draft invitation to participate was sent to the NDoH and then to all the registered participants upon receiving the go-ahead.

The results obtained are presented in the Table below. An obvious error was included in evaluating the participants' attention to the content, and all participants indicated that it should be excluded.

Table 1-2: Round 1: Verification feedback

Item	Access to Medication List	Alerts and notifications	Alignment between the DHIS2, the Financial Management system, and PERSAL	Analytics through actionable data for Population Health Management	Billing	Bio surveillance	Care Plan Management	Clinical Coding	Clinical Research and Trial Management	Compliance testing of applications	Consent-based data access	Consultation and transfer of care	Curation and validation of terminologies and value set	Disease Surveillance	Electronic Discharge Summary	Electronic Health Record	Emergency response	ePrescribing and Medication Management	Healthcare provider lookup and validation	Health management information system (HMIS) for HIV/TB and other nationally prioritised health	Immunisation information management	Laboratory request and result reporting and workflow	Maternal and childcare management	Medication management	Mobile services	Mobility of Patient Records	Multi-disciplinary consultations	National Aggregate Reporting	Operation Management and supply logistics	Patient identity lookup and validation	Quality assessment and reporting	Radiology reporting and results sharing	Referral and discharge reporting	Remote monitoring	Secure Messaging	Transition of Care	Validation of facility data
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Answers	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	n	n	y	n	y	y	y	y	y	y	y	y	n	y	y	y	y
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	y	y	y	y	n	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y

Item	Access to Medication List	Alerts and notifications	Alignment between the DHIS2, the Financial Management system, and PERSAL	Analytics through actionable data for Population Health Management	Billing	Bio surveillance	Care Plan Management	Clinical Coding	Clinical Research and Trial Management	Compliance testing of applications	Consent-based data access	Consultation and transfer of care	Curation and validation of terminologies and value set	Disease Surveillance	Electronic Discharge Summary	Electronic Health Record	Emergency response	ePrescribing and Medication Management	Healthcare provider lookup and validation	Health management information system (HMIS) for HIV/TB and other nationally prioritised health	Immunisation information management	Laboratory request and result reporting and workflow	Maternal and childcare management	Medication management	Mobile services	Mobility of Patient Records	Multi-disciplinary consultations	National Aggregate Reporting	Operation Management and supply logistics	Patient identity lookup and validation	Quality assessment and reporting	Radiology reporting and results sharing	Referral and discharge reporting	Remote monitoring	Secure Messaging	Transition of Care	Validation of facility data
nr	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	29	30	31	32	33	34	35	36	37	38
	y	y	y	n	n	n	y	y	n	y	y	n	y	n	n	y	n	y	y	y	n	y	n	y	y	y	n	y	n	y	n	n	n	n	y	n	y
	y	y	y	y	y	n	y	y	y	n	y	y	n	y	y	y	y	y	y	y	y	y	y	y	y	n	n	n	n	y	n	y	y	y	y	y	y
	y	y	n	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	n	n	y	n	y	n	y	y	y	n
	y	n	y	y	y	n	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	n	y	y	y	y	y	y	y	y	y	y
	y	y	n	y	y	n	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	n	n	y	n	y	y	y	y	y	n
	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y
	y	y	y	y	n	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y
	Totals																																				
nr	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**
No	0	4	8	2	7	12	1	0	4	4	0	3	5	2	3	1	3	0	2	0	4	1	3	1	2	2	8	10	11	0	10	2	6	5	2	3	6
Yes	25	21	17	23	18	13	24	25	21	21	25	22	20	23	22	24	22	25	23	25	21	24	22	24	23	23	17	15	14	25	15	23	19	20	23	22	19

One item was removed *[28. Manicure],* as it was irrelevant. In this study, we conducted a statistical analysis to determine whether most respondents consider various items relevant. Each item was rated with either 'yes' (indicating importance) or 'no' (indicating lack of importance), and the proportion of 'yes' responses was used to evaluate the relevance of each item. To formally test whether the proportion of 'yes' responses was significantly greater than 50%, we performed a one-sample proportion z-test.

1.4.1 Step 1: Hypotheses

We established the following hypotheses for each item:

- Null Hypothesis (H_0): The proportion of respondents who consider the item relevant is 50% ($p_0 = 0.50$).
- Alternative Hypothesis (H_1): The proportion of respondents who consider the item relevant is greater than 50% ($p > 0.50$).

This hypothesis test helps us determine whether the sample proportion of 'yes' responses ($\hat{p}$) is significantly greater than the hypothesised proportion of 50%.

1.4.2 Step 2: Sample Proportion

For each item, the sample proportion of 'yes' responses was calculated using the formula:

-$\hat{p}$ = (Number of 'yes' responses) / (Total number of responses)
For example, if an item received 21 'yes' responses out of 25 total responses, the sample proportion is:
-natuurlik
$\hat{p} = 21 / 25 = 0.84$

1.4.3 Step 3: Z-Score Calculation

A z-test was applied to assess the relevance of each use case to determine whether the proportion of respondents who viewed each use case as important was significantly greater than 50%. The formula for the z-score is:

$$z = (\hat{p} - p_0) / \sqrt{[(p_0(1 - p_0)) / n]}$$

Where:
- $\hat{p}$ is the sample proportion,
- p_0 is the hypothesised proportion (0.50),
- n is the total number of responses, and
- $\sqrt{[(p_0(1 - p_0)) / n]}$ is the standard error of the proportion.

The statistical results guided the elimination of use cases with low consensus, focusing the study on those with broader agreement, ensuring that each use case received robust participant support. While all use cases demonstrated sufficient relevance, the z-test provided a quantitative measure of consensus, confirming that each use case met the threshold for inclusion in the prioritisation process.

1.4.4 Step 4: P-Value and Decision Rule

The p-value was calculated for each item, which represents the probability of obtaining a z-score as extreme as the observed one if the null hypothesis were true. If the p-value is below a predetermined significance level ($\alpha = 0.05$), we reject the null hypothesis and conclude that the item is significantly relevant.

For example, for a z-score of 3.4, the p-value is less than 0.05, leading us to reject the null hypothesis and conclude that more than 50% of respondents consider the item important.

Table 1-3: Items, relevance and significance

Item Number	Yes	No	Yes Percentage	Relevant	Z-Score	P-Value	Significant
1	25	0	100	TRUE	inf	0	TRUE
2	21	4	84	TRUE	4.63713	1.77E-06	TRUE
3	17	8	68	TRUE	1.929359	0.026843	TRUE
4	23	2	92	TRUE	7.740703	4.94E-15	TRUE
5	18	7	72	TRUE	2.449895	0.007145	TRUE
6	13	12	52	TRUE	0.20016	0.420678	FALSE
7	24	1	96	TRUE	11.73714	4.11E-32	TRUE
8	25	0	100	TRUE	inf	0	TRUE
9	21	4	84	TRUE	4.63713	1.77E-06	TRUE
10	21	4	84	TRUE	4.63713	1.77E-06	TRUE
11	25	0	100	TRUE	inf	0	TRUE
12	22	3	88	TRUE	5.846846	2.50E-09	TRUE
13	20	5	80	TRUE	3.75	8.84E-05	TRUE
14	23	2	92	TRUE	7.740703	4.94E-15	TRUE
15	22	3	88	TRUE	5.846846	2.50E-09	TRUE
16	24	1	96	TRUE	11.73714	4.11E-32	TRUE
17	22	3	88	TRUE	5.846846	2.50E-09	TRUE
18	25	0	100	TRUE	inf	0	TRUE
19	23	2	92	TRUE	7.740703	4.94E-15	TRUE
20	25	0	100	TRUE	inf	0	TRUE
21	21	4	84	TRUE	4.63713	1.77E-06	TRUE
22	24	1	96	TRUE	11.73714	4.11E-32	TRUE
23	22	3	88	TRUE	5.846846	2.50E-09	TRUE
24	24	1	96	TRUE	11.73714	4.11E-32	TRUE
25	23	2	92	TRUE	7.740703	4.94E-15	TRUE
26	23	2	92	TRUE	7.740703	4.94E-15	TRUE
27	17	8	68	TRUE	1.929359	0.026843	TRUE
29	15	10	60	TRUE	1.020621	0.153717	FALSE
30	14	11	56	TRUE	0.604367	0.2728	FALSE
31	25	0	100	TRUE	inf	0	TRUE

32	15	10	60	TRUE	1.020621	0.153717	FALSE
33	23	2	92	TRUE	7.740703	4.94E-15	TRUE
34	19	6	76	TRUE	3.043904	0.001168	TRUE
35	20	5	80	TRUE	3.75	8.84E-05	TRUE
36	23	2	92	TRUE	7.740703	4.94E-15	TRUE
37	22	3	88	TRUE	5.846846	2.50E-09	TRUE
38	19	6	76	TRUE	3.043904	0.001168	TRUE

For each item, the one-sample proportion z-test was applied to determine whether the proportion of respondents who considered the item relevant was significantly greater than 50%. The results showed that most tested items had a p-value below the 0.05 significance level, leading us to reject the null hypothesis for all but a few items. Consequently, we would exclude items 6, 29, 30, and 32, but most respondents considered all other items relevant. Further refinement is outlined below concerning Linking, Candidate National Use Cases and Semantics.

1.4.5 Additional Feedback

The following are additional comments that respondents noted. Several comments involved linking some candidate National Use Cases to refine the list. The following table provides the further refinement that was suggested as linked items.

Table 1-4: Further refinement suggested as linked items

Linking
15 & 34 [15] Electronic Discharge Summary [34] Referral and discharge reporting
1 & 24 [1] Access to Medication List [34] Referral and discharge reporting
19 & 38 [19] Healthcare provider lookup and validation [38] Validation of facility data
34 & 37 [34] Referral and discharge reporting [37] Transition of Care
Numbers 1,5,7.11, 12, 15, 17,18, 20,21,23,24,25,26,27,31,34,34 link to 16. When identifying standards for patient care modules, all should be viewed with the same standards. [1] Access to Medication List [5] Billing [7] Care Plan Management [11] Consent-based data access [12] Consultation and transfer of care [17] Emergency response [18] ePrescribing and Medication Management [20] Health management information system (HMIS) for HIV/TB and other nationally prioritised health conditions [21] Immunisation information management [23] Maternal and childcare management

Linking
[24] Medication management [25] Mobile services [26] Mobility of Patient Records [27] Multi-disciplinary consultations [31] Patient identity lookup and validation [34] Referral and discharge reporting [16] Electronic Health Record
No 18 ePrescribing and medication management and 24 Medication management. No 18 should be enough to as ePrescribing system should form part of interoperable systems to manage writing (sic) and sending of prescriptions for better management of medication [18] ePrescribing and Medication Management [24] Medication management
link 1 and 18 [1] Access to Medication List [18] ePrescribing and Medication Management
link 37, 34, 12 and 15 [37] Transition of Care [34] Referral and discharge reporting [12] Consultation and transfer of care [15] Electronic Discharge Summary
link 1, 11, 16 [1] Access to Medication List [11] Consent-based data access [16] Electronic Health Record
National Use Case of Egypt for Universal Health Insurance Program to automate all the health care facilities from a medical point of view and link it automatically to the Universal Health Insurance Authority to submit automatic claims through the Dedalus Health Information Exchange Platform
3, 6 and Mobility of Patient Records can all be merged. 31, 33 can also be linked. [3] Alignment between the DHIS2, the Financial Management system, and PERSAL [6] Bio surveillance [31] Patient identity lookup and validation [33] Radiology reporting and results sharing
Some of the use case themes need clarity - the transition of care, remote monitoring, manicuring, and mobile services are not clear
none

Respondents further suggested adding some items as they had either not been mentioned or added in the first round. Below these suggestions were captured.

Table 1-5: Omitted items according to the respondents

Question from the questionnaire: Should there be any Candidate National Use Case that is omitted, please add it and, should it be an expansion of an existing one, indicate it.	Action taken
Chronic Medicines Dispensing & Distribution	
Major healthcare technology and international categorisation, such as MRI, CT scans, heart sonars, etc.	
Referral notes of patients	
I did not see the Health Patient Registration System;	Integration of the Master Patient Index (MPI)

Question from the questionnaire: Should there be any Candidate National Use Case that is omitted, please add it and, should it be an expansion of an existing one, indicate it.	Action taken
It makes sense to link demographic data with other clinical data to support the tracking of patients across multiple settings. Plus, HPRS has the standard master patient index, which should be used through the interoperability models	
Document Sharing as a backbone for 15, 16, 18, 22 and 33	
The International Patient Summary	
Security and Audit Logging	
Clinical notes and Summaries	
Alignment between the DHIS2, the Financial Management system, and PERSAL. This excludes provincial/local spheres. For SAPRIN, for example, we want to link populations to their educational records (household), SASSA, and local clinics and hospitals. These needs expanding.	
Human resource planning linked to patient management and quality of care	
Beneficiary registration/validation and lookup for health insurance workflows.	General health insurance workflows

Some comments had to do with the semantics of the statements. These are noted below.

Table 1-6: Semantics of the statements

Question from the questionnaire: Should there be a Candidate National Use Case that needs to be re-articulated, as it does not read correctly, please correct it.
19. Healthcare provider lookup and validation - Perhaps we should think of a primary key for healthcare providers which uniquely identifies them and links them with patients/services they have offered. "Healthcare provider Unique Identifier"
38. Compliance testing (10) of applications is more of a process than a use case. Electronic Health Record (16) is a tool and doesn't describe a use case -- either it needs better clarification or to be omitted. (20) reads poorly -- what is being asked here, and what should be included? (25) What does it refer to? Mobile clinics or cell phones- please be more precise. Manicures (28) -- either a typo and needs clarification or a poor input. (32) QA and reporting of what? (35) Remote monitoring of hardware at sites? Of whom? Patients or staff?

A Consolidated list was produced and is presented. The list will be macro-ranked using an adapted MoSCoW method.

The adaptions to the original MoSCoW method to produce the adapted MoSCoW method for Candidate National Use Cases are presented in the Table below, and an explanation of the differences is provided.

Table 1-7: Original and adapted MoSCoW categories

MoSCoW Category	Original MoSCoW	Adapted MoSCoW
Must have	Critical requirements that are essential for success. Without these, the project would fail.	These are the most critical Candidate National Use Cases, essential for the initial steps in evolving the shared National Health Information System.

MoSCoW Category	Original MoSCoW	Adapted MoSCoW
Should have	Important but not critical requirements. Their absence may cause inconvenience but will not cause project failure.	These use cases are important but not urgent and should be addressed in the medium term to enhance the system.
Could have	Desirable features that enhance the project but are not necessary for success. They can be included if time and resources allow.	These use cases are desirable and add value, but they are considered long-term developments for the shared National Health Information System.
Won't have	The least critical features will not be included in the current project scope but may be revisited in the future.	These use cases are the least critical or inappropriate at the time and will be reassessed as the system evolves.
Additional Factor	Not included in the original MoSCoW method.	Self-estimation of confidence: Added to gauge respondents' confidence levels in their prioritisation decisions based on a suggestion from a statistician.

An adapted MoSCoW was considered appropriate as:

- Expanded Focus on Candidate National Use Cases: In the adapted version, the MoSCoW method has been explicitly tailored for Candidate National Use Cases related to developing a shared National Health Information System. Each category is quantified with specific instances, indicating how many use cases fall into each category. This provides a more data-driven perspective than the original MoSCoW method, which is typically more qualitative.
- Timeframe for Implementation: The adapted version adds a sense of timing to the categories, such as considering Must have items essential in the initial steps and viewing Should have items as part of the medium-term plan. This contrasts with the original MoSCoW method, which focuses on the level of necessity without specifying a timeframe.
- Long-Term Focus for Could have: In the adapted version, the Could have category is associated with long-term developments for the National Health Information System. This is more specific than the original MoSCoW, which leaves Could have features as merely optional enhancements.
- Reassessment for Won't have: In the adapted method, Won't Have items are marked for periodic reassessment as the system matures, implying a future reconsideration. The original MoSCoW method typically excludes Won't have features from the current scope without mentioning reassessment.
- Self-Estimation of Confidence: The adapted method includes an additional component: a self-estimation of confidence, which was not present in the original MoSCoW method. This feature was added to gauge how confident respondents were in their prioritisation decisions, introducing a metric of reliability and self-assessment into the process.

The Idea Generation phase laid the groundwork for identifying a wide array of potential National Interoperability Use Cases. These diverse ideas formed the basis for further verification, ensuring that only the most relevant and feasible use cases were carried forward for deeper assessment. Following verification, the Assessment and Ranking phase allows for a refined evaluation of the

remaining use cases, using systematic methods to determine their relative importance in achieving a robust National Health Information System.

The Verification iteration confirmed the relevance of the suggested National Use Cases, refined their definitions, and incorporated additional suggestions. A deliberate error was included as a quality control measure, which all participants successfully identified, ensuring the integrity of responses.

1.5 Round 2: Assessment and Ranking

From round one, 1 item was considered irrelevant, three items were identified as insignificant, various items were consolidated, and some items were rephrased. A consolidated list was constructed and sent out to respondents for evaluation. The consolidated list and the responses captured are presented in the table below.

Table 1-8: Consolidated list of the outcome from Round 1

	Consolidated Candidate National Use Cases	Notes	Must have	Should have	Could have	Won't have
1	Electronic Discharge Summary	Includes Electronic transfer	20	25	16	0
2	Electronic Medication	To provide continuity of medication through medication management Incorporates ePrescription and eDispensing, addressing the logistic aspects related to prescriptions and dispensing Incorporates Shared medication treatment plan Patient's consent Distributed eMedication document repositories storage and access	40	15	6	0
3	Shared medication treatment plan	Provide a current comprehensive overview of the healthcare beneficiary's historical, present and projected medication needs.	25	30	6	0
4	Electronic Health Record	To provide a global view of the health of an individual. It incorporates sharing health-related documentation, i.e., the health record of the individual who traverses care sites, geographies and healthcare providers. Patient-centric as access is controlled by individuals. Incorporates and aggregates Electronic Medical Records (as the personal medical and treatment history at a single Healthcare provider) Incorporates administrative and billing data Incorporates patient demographics Incorporates shared medication treatment plan Healthcare-related artefacts such as Radiology images, Lab and test results	45	12	4	0
5	mHealth	MHealth describes healthcare-related products and services (including information) that are supported by mobile devices and focus on health and fitness. Excludes devices associated with the South African Health Products Regulatory Authority or diagnostic. This includes processes and services to incorporate value-added services and information access. Includes access to validated services Includes sharing with Health practitioners	15	32	11	0
6	eHealth Communication	Provision of health-related alerts and notification	15	35	6	0
7	Alignment between the DHIS2, the Financial Management system, and PERSAL.	System Integration is seen as a function of interoperability Information and or document sharing	50	8	3	0
8	Clinical Trail management	Coordinating and administrating efforts related to planning, controlling, monitoring, financing and recording clinical trials.	10	15	36	0
9	Clinical Coding	Provision and populating a data dictionary to provide a single lookup service to standardised clinical codes within the South African Healthcare ecosystem. Includes finding and using a common set of clinical codes.	40	18	3	0

	Consolidated Candidate National Use Cases	Notes	Must have	Should have	Could have	Won't have
		Curation and validation of terminologies and value sets				
10	Population Health Management and monitoring	Utilisation of Business Intelligence in interpreting patient data and monitoring care processes. This includes the clinical, financial, and operational data coalition to provide actionable insights. Includes analytics. Provision of value-based care (patient-generated data, social determinants of health, environmental and genetic data available). Aggregation of data on disease, outbreak, and spread for actionable insights.	45	15	1	0
11	Emergency response	Includes continuation of patient care when healthcare infrastructure has been damaged Includes initiation and transfer of healthcare from locations to institution Remote and offline emergency accessibility of patient medical information (term EHR not used to facilitate in avoiding a hierarchical bias) This includes retrieving medical records, temporarily allocating new ones, and ensuring consistency.	28	30	3	0
12	Healthcare provider lookup	Includes current validation	25	32	4	0
13	Healthcare facility lookup	Includes current validation	45	13	3	0
14	Shared healthcare treatment management plan.	Provide a comprehensive overview of historic, present and projected healthcare interventions, events and medication related to healthcare beneficiaries. Includes maternal and childcare management Includes chronic disease management Includes immunisation management	35	20	6	0
15	Healthcare event management	Coordinate and administer efforts related to planning, controlling, monitoring, financing, and recording healthcare-related events. Include radiology referral, result reporting and sharing. Include laboratory referral, result reporting and sharing.	40	15	6	0
16	Remote patient management	Delivery of services to remote locations and/or home care populations	22	30	9	0

•

1.5.1 Clusters

After an initial round of engagement, the survey response level was deemed too low, prompting a redistribution of the form. Subsequent rounds of data collection yielded 67 total engagements, of which 61 were complete responses, and seven were incomplete. The average confidence level among participants was reported as somewhat confident. Notably, the participant pool primarily consisted of health practitioners rather than ICT Health specialists, which may have influenced response dynamics. This aligns with previous studies that emphasise the importance of high response rates in survey research, particularly when exploring perceptions of healthcare technologies (Al-Rjoub et al., 2023; Rogove et al., 2012). Moreover, the difficulty of recruiting clinicians for technology-focused studies is well-documented, as they often face time constraints (Weichelt et al., 2019).

While challenges existed in engaging a balanced respondent pool, the response rate achieved was commendable, providing a strong basis for further analysis. The primary goal moving forward was to systematically organise and prioritise use cases based on their perceived importance and feasibility, which was accomplished through K-means clustering (Luchenski et al., 2012).

The primary objective was to organise and prioritise use cases by their assigned importance across four categories: *Must have*, *Should have*, *Could have*, and *Won't have*. To facilitate this, K-means clustering, an unsupervised machine learning method, was employed to group use cases based on their importance and feasibility (Ikotun et al., 2023). This data-driven approach enabled objective categorisation, distinguishing foundational elements from those considered desirable but not critical. The four specified clusters corresponded to the priority categories, offering guidance for phased NHIS implementation and reflecting both immediate needs and longer-term goals.

The data for clustering comprised numerical values that indicated how each use case was rated across the four categories. These values represented the extent to which each use case was deemed necessary or optional for implementation. The K-means algorithm minimises intra-cluster differences while maximising inter-cluster distinctions (Pulkit, 2024), iteratively grouping use cases based on similarity in priority values until optimal clusters were identified.

To enhance the visualisation of the clustering outcomes, Principal Component Analysis (PCA) was utilised (Greenacre et al., 2022). By reducing the four-dimensional data (*Must have*, *Should have*, *Could have*, and *Won't have*) to two dimensions, PCA facilitated a clearer representation of how use cases were grouped. The resulting scatter plot (Figure 1-3) illustrates the clusters, with different colours representing the distinct groups identified.

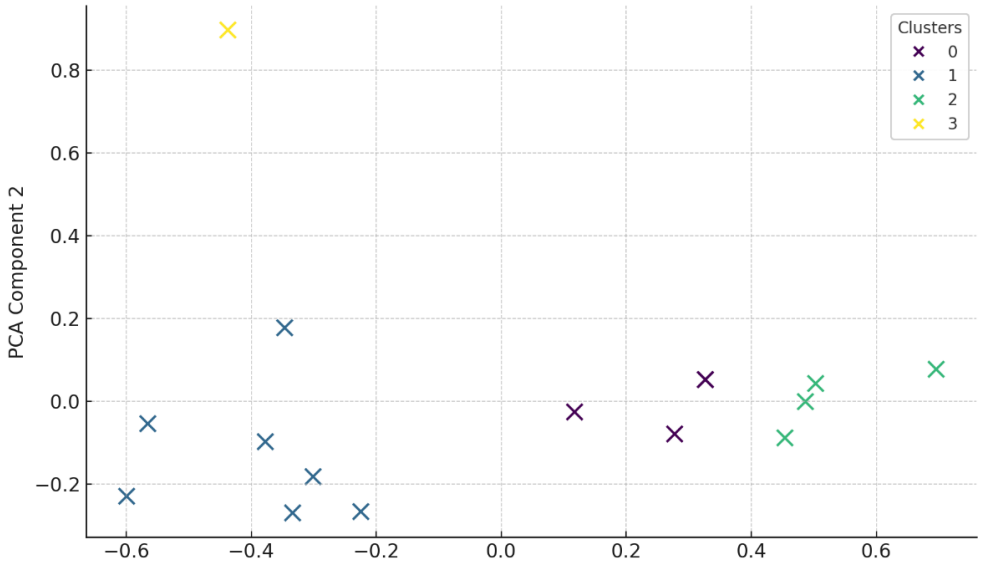

Figure 1-3: K-Means Clustering of Use Cases

The K-Means clustering successfully divided the use cases into four distinct clusters. Each cluster contained use cases with similar importance levels across the four priority categories. The scatter plot generated from the PCA analysis highlights the separation of use cases into these clusters, providing a clear visual representation of the categorisation. This clustering approach offers a data-driven method for prioritising use cases, facilitating decision-making based on objective analysis rather than subjective judgment.

Table 1-9: Use Case clustering

Use Case	*Must have*	*Should have*	*Could have*	Cluster
Electronic Medication	40	15	6	0
Clinical Coding	40	18	3	0
Shared healthcare treatment management plan	35	20	6	0
Healthcare event management	40	15	6	0
Electronic Discharge Summary	20	25	16	1
Shared medication treatment plan	25	30	6	1
mHealth	15	32	11	1
eHealth Communication	15	35	6	1
Emergency response	28	30	3	1
Healthcare provider lookup	25	32	4	1
Remote patient management	22	30	9	1
Electronic Health Record	45	12	4	2
Alignment between DHIS2, Financial Management, PERSAL	50	8	3	2
Population Health Management and monitoring	45	15	1	2
Healthcare facility lookup	45	13	3	2
Clinical Trial management	10	15	36	3

Based on the K-means clustering, each cluster group uses cases with similar profiles in terms of *Must have*, *Should have*, and *Could have* values. Each cluster is unpacked below based on the characteristics of the use cases it contains:

1.5.1.1 Cluster 0: High Must have and Balanced Needs

This cluster contains use cases with relatively high *Must have* requirements and a balanced distribution across the *Should have* and *Could have* categories. *These use cases are considered critical and foundational* but also have additional optional features that could improve their effectiveness, such as:

- Electronic Medication: Ensures continuity and safety in medication management, making it critical but with room for additional features.
- Healthcare Event Management: Manages important healthcare interactions like referrals and reports, which are essential but could be expanded with new capabilities.

1.5.1.2 Cluster 1: Medium Must have, High Optional Flexibility

Cluster 1 contains use cases with medium *Must have* importance but relatively higher values for *Should have* and *Could have* attributes. This suggests that these use cases are considered *moderately essential but benefit significantly from additional features and flexibility*. These use cases focus more on communication and patient data sharing across different healthcare processes.

- Shared Medication Treatment Plan: Critical for continuity of care, with a strong need for additional features like integration with other systems.
- Emergency Response: This is important for handling crises, but additional enhancements could make a big difference regarding remote and offline data access.

1.5.1.3 Cluster 2: Very High Must have, Low Flexibility

This cluster contains the use cases with very high *Must have* values, *indicating they are considered foundational or indispensable for the health system*. However, they have relatively low *Should have* and *Could have* requirements, implying they are highly focused and less reliant on extra features. These use cases could be considered as managing core healthcare systems like records, population health, and system alignment.

- Electronic Health Record: Central to the healthcare system, it integrates essential health documentation with minimal optional features.
- Alignment between DHIS2, Financial Management, and PERSAL: Critical for system interoperability, highly essential but less dependent on optional features.

1.5.1.4 Cluster 3: Low Must have, High Optional Features

Cluster 3 contains use cases with low *Must have* values, but high *Could have* flexibility, meaning they are less critical but could become highly beneficial with additional functionalities. These use cases are often secondary but can bring significant enhancements if improved with more advanced features.

- Clinical Trial Management: This is not a critical everyday operation, but adding features like better monitoring and financing could significantly improve its effectiveness.
- Other Optional Enhancements: This cluster can be seen as *nice-to-have* features that could significantly elevate the healthcare ecosystem but aren't essential.

1.5.2 Cluster Ranking

The ranking of the clusters from most important to least important is primarily based on the *Must have* attribute since it reflects the criticality of each use case. Outlined below are the clusters rank based on their overall *Must have* values:

1.5.3 Cluster Ranking Based on Importance:

- Cluster 2: Very High Must have, Low Flexibility – Most Important
    - Average Must have value: 46.25
    - Contains indispensable systems like Electronic Health Records and Alignment of DHIS2, Financial Management, and PERSAL.
    - These use cases are core to the healthcare infrastructure and can't be compromised, making them the most critical for system functionality.
- Cluster 0: High Must have and Balanced Needs – Second Most Important
    - Average Must have value: 35.6
    - Use cases like Electronic Medication and Healthcare Event Management are essential but with some flexibility in their additional features.
    - These systems are still foundational but might allow for gradual improvements.
- Cluster 1: Medium Must have, High Optional Flexibility – Moderately Important
    - Average Must have value: 21.6
    - These use cases, such as Shared Medication Treatment Plan and Emergency Response, have medium importance but could significantly benefit from enhancements.
    - While important, they are not as critical as the clusters above but provide vital communication and patient data management support.

- Cluster 3: Low Must have, High Optional Features – Least Important
    - Average *Must have* value: 10
    - This cluster includes use cases like Clinical Trial Management, which have low criticality but could greatly benefit from additional optional features.
    - These are secondary systems that are *nice-to-have* and enhance healthcare processes but aren't crucial to daily operations.

Each use case was analysed and presented in a table that ranks the use cases within each cluster based on the *Must have* value, starting from the most important nr 1 to the least important number 16. You can now view the complete ranked list in the displayed table below.

Table 1-10: Cluster ranking results

Cluster	Use Case	Must have	Should have	Could have
Cluster 2	Alignment between DHIS2, Financial Management, PERSAL	50	8	3
Cluster 2	Electronic Health Record	45	12	4
Cluster 2	Population Health Management and monitoring	45	15	1
Cluster 2	Healthcare facility lookup	45	13	3
Cluster 0	Clinical Coding	40	15	6
Cluster 0	Electronic Medication	40	18	3
Cluster 0	Healthcare event management	40	15	6
Cluster 0	Shared Healthcare Treatment Management Plan	35	20	6
Cluster 0	Remote Patient Management	22	30	9
Cluster 1	Emergency Response	28	30	3
Cluster 1	Shared Medication Treatment Plan	25	30	6
Cluster 1	Healthcare Provider Lookup	25	32	4
Cluster 1	Electronic Discharge Summary	20	25	16
Cluster 1	mHealth	15	32	11
Cluster 1	eHealth Communication	15	35	6
Cluster 3	Clinical Trial Management	10	15	36

1.6 Round 3: Assessment and Ranking

To validate the statistical rankings established in Round 2, each cluster was redistributed to participants for further ranking. Of the 69 responses collected, duplicate and incomplete entries were removed, resulting in 54 complete and usable responses for analysis.

This refined set of responses was then processed using the Kemeny-Young method, an advanced algorithm designed to identify the ranking that best aligns with participants' combined preferences. The Kemeny-Young method compares each pair of scenarios (e.g., A vs. B, A vs. C) based on participant rankings. For each pair, it calculates the frequency with which participants ranked one

scenario higher than the other. The algorithm then generates all possible rankings of the scenarios; for instance, with four scenarios, there are 24 possible rankings (4!).

To determine the optimal ranking, the method calculates the "disagreement" or distance for each possible ranking by counting how many pairwise preferences each ranking violates. The optimal ranking is the one that minimises this total disagreement, providing a theoretically ideal compromise that reflects group consensus. Grounded in decision theory, the Kemeny-Young method is therefore considered to deliver a ranking that best represents the collective preferences, minimising disagreement and offering a statistically sound compromise (Emerson, 2023)

The ranking for the *Must have* grouping was found to be:

Electronic Health Record > Healthcare facility lookup > Alignment between DHIS2, Financial Management, PERSAL > Population Health Management and monitoring

Similarly, the *Should have,* and the *Could have* groupings were calculated, and the outcome is presented in Table 1-11:

Table 1-11: Ranked Candidate National Use Cases.

Most Important: Very High *Must have* , Low Flexibility
Electronic Health Record
Healthcare facility lookup
Alignment between DHIS2, Financial Management, PERSAL
Population Health Management and monitoring
Second Most Important: High *Must have* and Balanced Needs
Electronic Medication
Clinical Coding
Healthcare event management
Shared Healthcare Treatment Management Plan
Remote Patient Management
Moderately Important: Medium *Must have* , High Optional Flexibility
Emergency Response
Shared Medication Treatment Plan
Healthcare Provider Lookup
Electronic Discharge Summary
mHealth
eHealth Communication
Least Important: Low *Must have* , High Optional Features
Clinical Trial Management

Round 3 effectively synthesised the gathered insights and allowed for ranking use cases based on their importance to the National Health Information System. The Kemeny-Young Method for ranking facilitated a consensus-driven ordering, presenting the priority of use cases.

1.7 Round 4: Evaluation and Communication

The Evaluation and Communication phase includes validating, contextualising, and refining the prioritised use cases identified in previous rounds. The consistency of stakeholder rankings was measured using Kendall's W, a coefficient of concordance that reflects the level of agreement among participants (Rico et al., 2023). This is followed by an expert review with purposefully selected domain experts, whose feedback will refine and contextualise the use cases. The selection of experts was purposeful to ensure comprehensive evaluation across critical domains. A government health official was chosen to provide policy and regulatory oversight, a health information technologist for insights on system integration and technical feasibility, and a representative of external healthcare services to address practical application in clinical and reimbursement contexts. This diverse selection was designed to balance policy, technology, and service delivery perspectives, ultimately refining the prioritised use cases through well-rounded and practical feedback. This phase aims to provide a solid empirical document for the NDoH to develop a robust National Health Information System by combining statistical validation and targeted expert insights.

1.7.1 Ranking Agreement

Kendall's W (also known as Kendall's coefficient of concordance) is used to assess the agreement between raters when ranking items (Emerson, 2023).

Kendall's W (Coefficient of Concordance) measures the degree of agreement among raters (participants) regarding the ranking of scenarios (Roch et al., 2009; Rico et al., 2023). Kendall's W ranges from 0 (no agreement) to 1 (perfect agreement). The following is the formula for Kendall's W:

$$\boldsymbol{W} = \frac{(\mathbf{12} \times \boldsymbol{S})}{(\boldsymbol{m}^{\mathbf{2}} \times (\boldsymbol{n}^{\mathbf{3}} - \boldsymbol{n}))}$$

Where:
m = number of participants (raters)
n = number of scenarios (items) being ranked
S = sum of squared deviations of the rank sums for each item from the mean rank sum
Applying this to the current investigation:

Sum of squared deviations (S): 10988.0000
Number of participants (m): 56
Number of scenarios (n): 4

The Kendall's W value is $W = 0.7008$

A Kendall's W value of 0.7008 suggests a high degree of agreement among the participants regarding the ranking of the candidate use cases. It shows that the rankings are predominantly consistent, and the participants generally agree on the ranked order of the candidate use cases.

1.7.2 Experts' Biographies and Their Feedback

This round of developing the National Health Information System use cases was guided by a purposeful sampling approach to ensure that the expert review phase incorporated a diverse range of relevant perspectives (Perla & Provost, 2012). The goal was to select individuals who possessed deep expertise in different facets of health information systems, enabling comprehensive feedback to refine the prioritised use cases. Purposeful sampling ensured that the expert review phase drew upon a diverse range of directly relevant perspectives. The goal was to select individuals who possess deep expertise in different facets of health information systems, providing well-rounded feedback to refine the prioritised use cases. The chosen experts represent key stakeholder groups: a government health official with policy and regulatory oversight, a technologist specialising in designing and applying health information systems, and a representative from an external healthcare service provider. This strategic selection aimed to ensure that the evaluation incorporates perspectives on policy implications, technological feasibility, and practical implementation in healthcare settings (Salleh et al., 2021), offering comprehensive insights for refining the use cases.

1.7.2.1 Respondent 1: Health Government Official

Biography: Respondent 1 holds a senior position in the National Department of Health, with significant expertise in health policy implementation and digital health strategies and has over 15 years of experience in health system governance and policy development.

Feedback Summary: Respondent 1 commended the structured approach in identifying and ranking the use cases, appreciating the alignment with national health priorities, particularly in areas like Electronic Health Records (EHR). They emphasised scalability and adaptability across regions, given the diverse landscape of the national health system. The respondent also recommended considering the social determinants of health and the system's impact on chronic disease management. Finally, they suggested early policy engagement to ensure the successful implementation and sustainability of the use cases.

1.7.2.2 Respondent 2: Technologist with Health Information Systems Experience

Biography: Respondent 2 is an expert in health informatics, focusing on designing and implementing Health Information Systems (HIS) across private and public healthcare sectors. They have led various projects in Health Information System implementations, providing technology solutions and interoperability expertise.

Feedback Summary: Respondent 2 provided feedback from a technical perspective, highlighting the importance of achieving interoperability within the ranked use cases, particularly for complex data-sharing scenarios. They emphasised the need to standardise data models to avoid fragmentation and inconsistencies. Respondent 2 also underscored the importance of user experience, recommending thorough training for healthcare professionals. The suggestion to build flexibility into the system was aimed at ensuring its evolution in line with advancing health technologies.

1.7.2.3 Respondent 3: Representative of External Medical Service Provider

Biography*:* Respondent 3 is a senior operations executive at a medical service provider, responsible for healthcare reimbursement systems, provider network management, and care coordination services. With a decade of experience, they bring a commercial and service delivery perspective to adopting and using health information systems.

Feedback Summary: Respondent 3 approached their feedback through the lens of service delivery efficiency and financial sustainability. They appreciated the focus on communication and data-sharing use cases, given their importance for care coordination and reimbursement. However, they recommended prioritising use cases that could reduce administrative burdens and improve claims processing. Caution was advised in integrating these use cases with existing systems, especially in private healthcare settings, and a phased approach was suggested to ensure smooth adaptation. The respondent emphasised the need for ongoing monitoring to ensure the system meets operational and patient care goals.

The feedback from the experts was instrumental in validating and contextualising the prioritised use cases. The government health official emphasised the importance of scalability and alignment with policy objectives, guiding refinements toward broader system integration. The technologist provided critical insights into the technical feasibility and user interface design, ensuring that interoperability standards were met without sacrificing usability. The external healthcare representative highlighted the operational impact, suggesting adjustments to improve care coordination and reimbursement processes. These perspectives were synthesised to refine the prioritised use cases, ensuring that the NHIS framework is both comprehensive and practical despite their feedback not warranting any significant change in priorities. The ranking was kept in the order it was from Round 3.

1.8 Conclusion

This study endeavoured to systematically identify and prioritise national interoperability use cases to inform the development of a robust national health information system (NHIS). The research sought to ensure that the prioritised use cases align with national health objectives and practical system needs by utilising a structured methodology involving rounds of stakeholder input, statistical analysis, and expert reviews. While comprehensive and built on solid consensus, as

indicated by Kendall's W, the findings represent a step forward in conceptualising how interoperability can be effectively integrated into national health data frameworks.

However, it is vital to acknowledge the limitations inherent in this research. While the Delphi process facilitated broad stakeholder engagement, the evolving landscape of health information technology may require continual reassessment of the identified use cases. Additionally, while providing valuable context, the purposeful sampling of experts represents perspectives that may benefit from further expansion to include a more diverse range of healthcare experiences and technological considerations.

The clustering and ranking methodologies, particularly the Kemeny-Young method, have allowed for an evidence-based prioritisation of use cases; however, the dynamic nature of health policy, technological capabilities, and healthcare needs necessitates an adaptive approach. It is hoped that the insights and recommendations outlined here will serve as a foundational framework for developing the NHIS, with the understanding that flexibility, continual evaluation, and stakeholder collaboration will be crucial in ensuring its successful implementation and relevance to a rapidly changing health environment. Future research should focus on refining these use cases as the system develops, ensuring that the NHIS remains responsive to both technological advancements and the evolving healthcare sector needs.

While this study has provided a systematic approach to prioritising National Interoperability Use Cases, it is important to recognise the need for continual reassessment as technology and health needs evolve. The use cases developed here are based on current policy and technological landscapes, which may shift in response to new developments and emerging health challenges. Further research is recommended to refine and expand the expert review process, engaging a broader range of stakeholders to ensure that the NHIS remains responsive to diverse healthcare contexts. Additionally, practical implementation challenges, such as system integration and stakeholder training, must be addressed as the use cases are operationalised.

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Chapter 2: Building the Digital Health Ecosystem Using the HMS² Health Information System: An Eastern Cape Department of Health Perspective

Moko, S.T.,[1,2] Rossouw, A.[1] and Strydom, A.[1]

[1]Eastern Cape Department of Health, [2]Walter Sisulu University

Purpose: *The healthcare landscape continually evolves, with digital technology pivotal in transforming healthcare delivery and management. This chapter explores the development and implementation of the HMS² (Health Management System) information system within the Eastern Cape Department of Health. It draws from implementation experiences in the Eastern Cape Department of Health and the Free State Department of Health. The HMS² system represents a significant step towards contributing to building a comprehensive digital health ecosystem.*

Study design/methodology/approach: *The study used a qualitative approach, where qualitative data collection techniques (interviews and discussions) with key stakeholders, system users, and department officials were used to provide the outcomes, impact, lessons learned and recommendations.*

Objectives: *The primary objectives were (a) to assess the HMS² information system's effectiveness in improving healthcare delivery (i.e. Improvement in Patient Administration and Revenue management and overall health outcomes) within the Eastern Cape Department of Health and the Free State Department of Health, (b), To identify the challenges and barriers encountered during the implementation of HMS², (c) To provide recommendations for optimising and expanding the digital health ecosystem in the Eastern Cape and potentially across South Africa.*

Findings: *The outcomes and impact of the Eastern Cape Department of Health eHealth steering committee's initiatives since the project's inception in September 2021 indicate a transformative journey in healthcare management and service delivery. The initial implementation efforts have yielded some tangible successes. As of 31 May 2024, Phase 1 modules have been successfully implemented in 38 hospitals across all levels of care in the province. This marks a significant milestone in strengthening patient administration and revenue management and putting in place the essential building blocks to proceed to HMS² phase 2 module implementations. The HMS² phase 1 modules were also implemented in 10 Free State Department of Health district hospitals on 31 March 2024. HMS² Phase 1 module expansion was also extended to include developing a module for three Emergency Medical Services (EMS) centres across the province, focussing on patient administration and revenue management. This expansion reflects the commitment to optimising patient care beyond*

hospital settings, incorporating emergency services into the comprehensive eHealth framework. As part of a pioneering pilot project, the eHealth steering committee introduced automated electronic registers in three Community Health Centres (CHCs) and six Primary Health Care (PHC) facilities. This innovative endeavour is a testament to the eHealth steering committee's forward-thinking approach and dedication to exploring new avenues for enhanced healthcare management.

Conclusion, from infrastructure upgrades to the successful deployment of HMS² modules, the eHealth system has enhanced patient care, operational efficiencies, and data-driven decision-making. As the phased implementation continues, the positive impact on healthcare delivery is poised to grow, reinforcing the commitment to excellence in the digital transformation of healthcare services.

Keywords: *Electronic Health, Electronic Health Records, Interoperability, Strategy*

2.1 Introduction, Purpose and Methodology

The Eastern Cape Department of Health pioneered the development of the in-house Electronic Health Management System (EHMS), commonly referred to as HMS² (Nkosi, 2021, October 16). This also marks a significant milestone in contributing to healthcare innovation in the Eastern Cape and South Africa (Wagner, 2020). This system, integral to the broader South African Digital Health ecosystem, represents an advancement in healthcare delivery, encapsulating the essence of the country's ambitious eHealth strategy (ECDoH, 2020). The system embodies the principles and goals of the South African Digital Health Strategy (NDoH, 2019).

As a foundational pillar of digital transformation, the system stands as a testament to the strategy's overarching mission to revolutionise healthcare through technology, accessibility, and enhanced patient-centric care (ECDoH, 2020). The system's strategic alignment with the South African digital Health Strategy is multifaceted and far-reaching. It serves as a linchpin in the strategy's objective to centralise patient information, enable seamless data exchange, and bolster healthcare infrastructure across public healthcare facilities (NDoH, 2019). By integrating various facets of healthcare delivery, the system fosters interoperability, breaking down silos between healthcare entities and paving the way for comprehensive, integrated care models (Zweni, 2023, January 30).

Furthermore, the system embodies the strategy's commitment to improving healthcare accessibility and quality. Its implementation within the Eastern Cape Department of Health, and subsequent extension to the Free State Department of Health, is an enabler for transformative changes (ECDoH, 2023). It facilitates improved decision-making by healthcare providers and streamlines administrative processes, ultimately focused on enhancing the efficiency and effectiveness of healthcare delivery. The system's capabilities transcend mere digitisation; it catalyses better health outcomes, optimised resource utilisation, and more data-driven decision-making (Nkosi, 2021,

October 16). Moreover, it epitomises the strategy's vision of leveraging technology to bridge healthcare disparities, particularly in underserved areas, prompting equity in access to quality care. In essence, the Eastern Cape Department of Health's initiative with the digital health landscape underscores the symbiotic relationship between local innovation and national strategy (Wagner, 2020).

As it synergises with and fortifies the South African National Digital Health strategy, this system stands as a testament to the transformative power of technology in shaping a healthier, more connected future for all South Africans.

2.1.1 The purpose

This chapter explores the development and implementation of the HMS² (Health Management System) information system within the Eastern Cape Department of Health. It draws from implementation experiences in the Eastern Cape Department of Health and the Free State Department of Health. The HMS² system represents a significant step towards contributing to building a comprehensive digital health ecosystem.

2.1.2 The methodology

This study employed a qualitative research design to gain a deeper understanding of the personal experiences and perspectives of individuals within a unique community setting (Cobigo et al., 2016). Therefore, data was collected through in-depth, semi-structured interviews with the Eastern Cape Department of Health's key stakeholders, system users, and department officials involved in developing and implementing the HMS^2.

Participants were selected using purposive sampling to ensure a diverse range of perspectives were represented, including individuals of different ages, backgrounds, and levels of involvement in the development of the HMS^2 (Daley et al., 2010).

Thematic analysis was used to identify common themes and patterns across the interview transcripts (Gallant et al., 2017; Syam et al., 2023). This iterative process involved thorough coding and re-coding of the data to uncover nuanced understandings of the participants' lived experiences.

The methodological approach focused on capturing contextual data to shed light on lessons learned and recommendations during the development and implementation of the HMS^2 (Campbell et al., 2021).

2.1.3 Chapter overview

The chapter will first provide an overview of the HMS^2 system and outline the components of this system by discussing the relevant modules associated with it. A strategic overview will be followed by an overview of how it was executed and implemented in the Eastern Cape Province. The critical eHealth building blocks (requirements analysis, infrastructure, connectivity, interoperability and

data exchange) will be discussed, followed by adopting a phased implementation strategy. Stakeholder engagement, outcomes, impact and lessons learned with recommendations will conclude this chapter.

2.2 Overview of the System

HMS² is a meticulously designed web-based solution ensuring secure and encrypted connectivity within a cloud-based infrastructure. The system's inception traces back to Frere Hospital, a tertiary healthcare facility in East London, Eastern Cape (ECDoH, 2020). Its development commenced in 2012 as a conceptual framework, evolving into initially an Electronic Medical Record (EMR) system designed to manage the comprehensive patient process flow within the hospital. A significant milestone was reached in 2021 when the Eastern Cape Department of Health's Head of Department approved the system's rollout and enhancement, initially targeting the implementation in 28 strategically selected facilities across the province (ECDoH, 2023). The primary goal was to establish robust electronic patient administration and revenue management systems across the hospital network. Since its implementation in 2021, the system has demonstrated remarkable growth and resilience, evolving from strength to strength (Zweni, 2023, January 30). Continuous enhancements have remained a focal point, propelled by an unwavering commitment to improving healthcare services. This dynamic evolution underscores the system's adaptability and ongoing contribution to advancing healthcare practices within healthcare facilities (ECDoH, 2023). Drawing inspiration from security protocols implemented in banking applications, HMS² employs a Secure Socket Layer (SSL) to ensure secure access to the system and safeguard data transmission between the application and the cloud (Keshvadi & Sharma, 2023). Notably, data stored in the database undergoes encryption, reinforced by additional layers of security meticulously implemented to protect user and patient data.

This comprehensive system encompasses various modules, primarily focusing on Electronic Medical records (EMR) and some Electronic Health Record (EHR) functionality (Zweni, 2023, January 30). Beyond EMR/EHR, it seamlessly integrates a diverse array of modular functionalities to streamline the management of various aspects, including but not limited to handling PAIA (Promotion of Access to Information) requests and managing Medico Legal claims (ECDoH, 2023). Therefore, the inherent versatility of HMS² positions it as a powerful and efficient tool for overseeing a broad spectrum of healthcare-related processes (Wolvaardt & Stewart, 2019). Notably, the system undergoes continuous development to introduce additional functionality and consistently improve features, enhancing effectiveness and efficiency. This commitment to ongoing refinement underscores the dedication to maintaining paramount principles of security and integrity, sustained through the robust architecture of its cloud-based framework. Importantly, the system was purposefully designed to accommodate virtual healthcare facilities, catering to all levels of care. This design facilitates the simplified onboarding of additional healthcare facilities, allowing them to share, for instance, a patient's medical record (Vena, 2016, April 5). The system operates on a role-based model ensuring the segregation of responsibilities, with permissions granted based on respective user role allocations. Various roles within the system enable

administrative and clinical staff to perform their specific functions efficiently and securely, as illustrated in Figure 2-1.

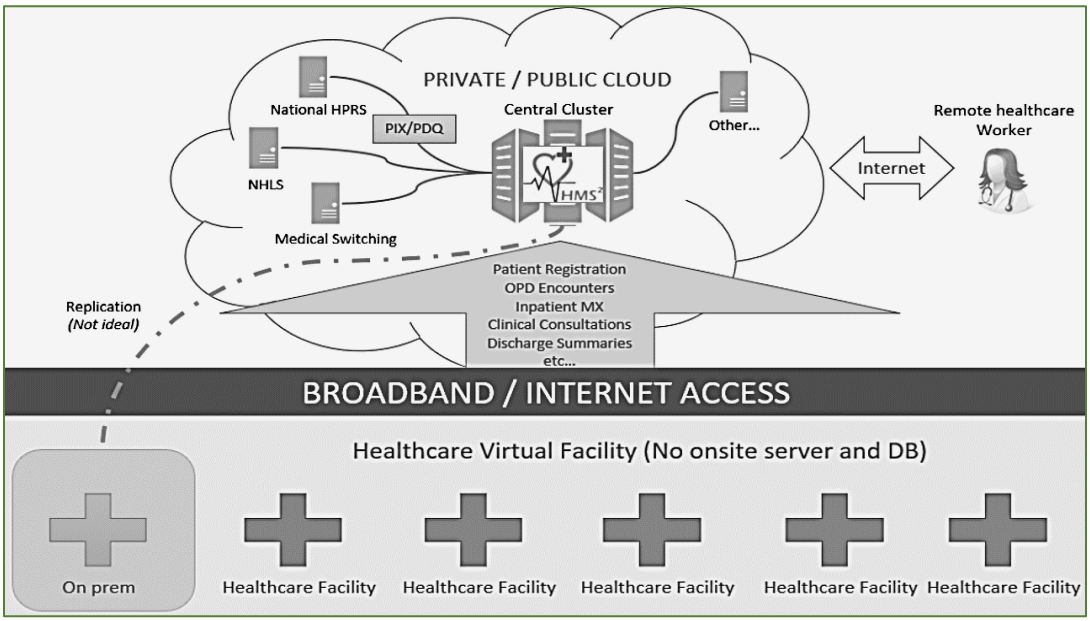

Figure 2-1: Virtualised Healthcare Facilities (NDoH, 2020)

Within the South African Health Normative Standards Framework (2020), the HMS² system serves

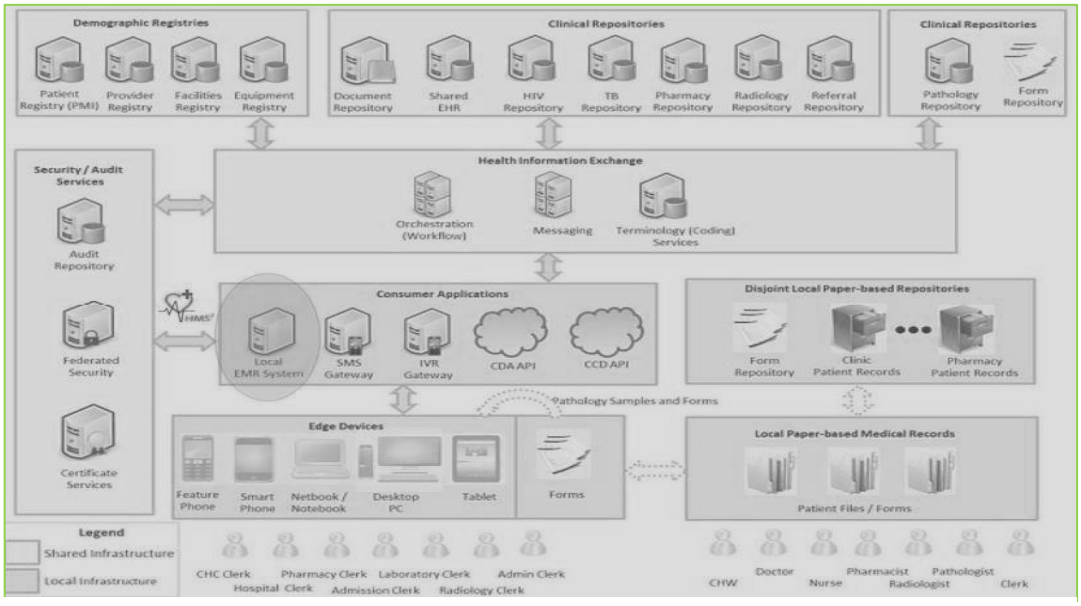

Figure 2-2: South African Health Normative Standard framework digital ecosystem (NDoH, 2020)

primarily as a provincial and healthcare facility consumer application. It facilitates the interaction and exchange of data with other systems within the digital health ecosystem, as illustrated in the Figure 2-2.

2.3 Outlining the HMS^2 system

The system can be divided into three main parts: Electronic Medical Record (EMR) with Electronic Health Record (EHR), Primary Modules that form part of the HMS2 and Theatre Slates Module. Additional modules are also mentioned.

2.3.1 Electronic Medical Record with Electronic Health Record Capabilities

This segment encompasses features and functionalities related to EMR with EHR functionality. It is dedicated to digitalising and effectively managing patient health records, emphasising efficiency and accuracy in healthcare documentation (ECDoH, 2023).

The system adheres to established coding standards, incorporating key frameworks such as the International Classification of Diseases (ICD) (WHO, 2010), the South African Master Facility List (MFL) (CSIR, n.d.), the South African Unified Patient Fees Schedule (UPFS) (WCDoH, 2020), and the South African National Stock Codes (NSN) for pharmaceuticals. As indicated above, these coding standards bring several notable benefits to the system and its users. The following benefits are important (ECDoH, 2023):

- Accuracy and Consistency: By aligning with established coding standards, the system ensures improved accuracy, interoperability, and data consistency across various healthcare components. This enhances the reliability of medical records, billing processes, and pharmaceutical management.
- Interoperability: Conforming to standardised coding systems facilitates interoperability between healthcare systems and institutions. This allows for seamless data exchange and communication, promoting collaborative and integrated healthcare delivery.
- Regulatory Compliance: Integration of coding standards ensures compliance with national and international healthcare regulations. This is crucial for accurate billing, regulatory reporting, and adherence to standardised healthcare practices.
- Efficiency in Data Retrieval: Standardised coding enables efficient retrieval of relevant information, whether it be for patient care, billing purposes, or inventory management. This streamlines workflows and contributes to more effective decision-making.
- Billing and Reimbursement: Coding standards, such as UPFS, facilitate accurate billing processes. It ensures that healthcare services are appropriately documented and billed, providing fair reimbursement for services rendered.
- Pharmaceutical Management: Incorporating South African National Stock Codes for pharmaceuticals enhances the efficiency of pharmaceutical management. It allows for accurately tracking of medication usage, stock levels and facilitates streamlined procurement processes.
- Quality Improvement: Standardised coding supports quality improvement initiatives by

providing consistent and structured data. This, in turn, enables healthcare providers to analyse trends, identify areas for improvement, and implement evidence-based practices.

Below are the primary modules.

2.3.2 Primary Modules That Form Part of the HMS² System

The primary modules of the HMS2 system are the patient registration, outpatient module and ward module.

2.3.2.1 Patient Registration

The patient registration module is intricately linked with the South African HPRS system through a currently approved one-way integration using the South African Health Normative Standards Framework (HNSF) and patient data query (PDQ) profile, as demonstrated in Figure 2-3 (NDoH, 2021). In the event of a patient presenting themselves at a healthcare facility, the system, based on specified criteria, electronically confirms the patient's existence in the HPRS.

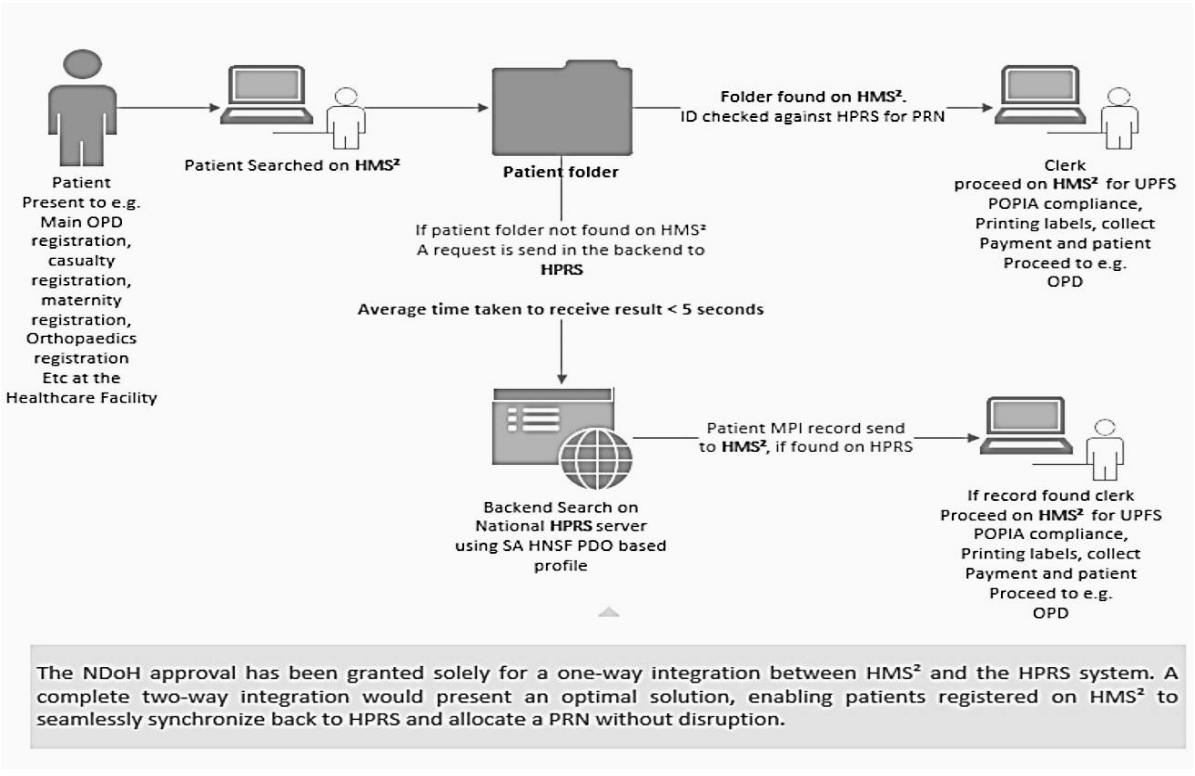

Figure 2-3: HMS² to HPRS Integration process flow (The researchers)

The HPRS patient demographic data and health patient registration number (HPRN) become the primary patient identifiers if the patient is identified (Genesis, 2019). In cases without HPRS or where bidirectional integration is not currently permitted, the HMS² system allocates a local HMS²

patient identifier. Efforts are underway to address this, particularly at the hospital level, by ideally implementing bidirectional integration or by having HPRS implemented on-premises, for instance, at a hospital to allow registration on HPRS to obtain the HPRN; this would facilitate the patient journey to proceed on HMS² (ECDoH, 2023). Figure 2-4 illustrates the search page of the HMS².

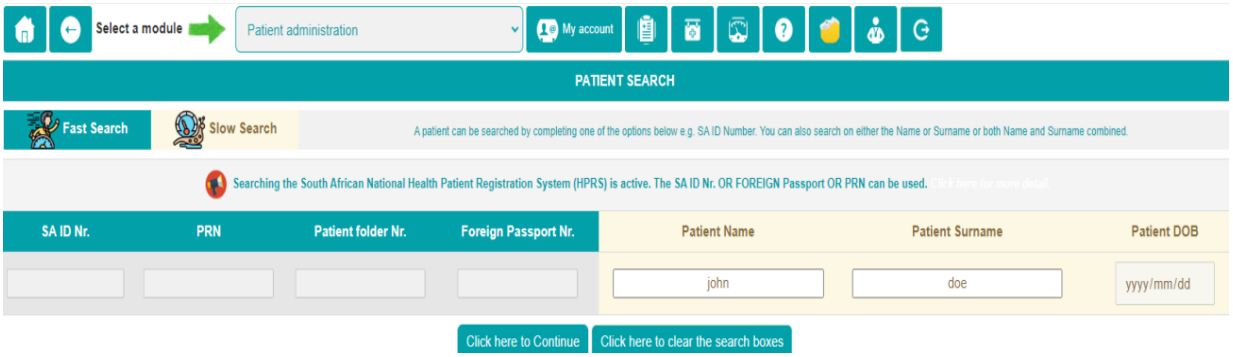

Figure 2-4:HMS² search page example (The Researchers)

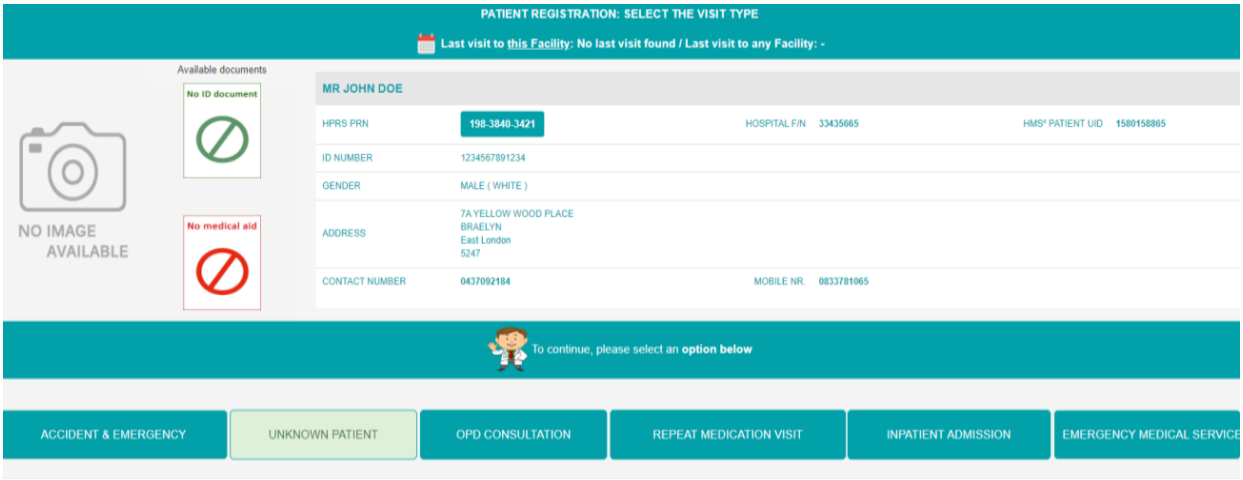

Figure 2-5: Services option selection (The Researchers)

The patient registration module ensures comprehensive registration, including patient demographic details, South African Unified Patient Fees Schedule (UPFS) (WCDoH, 2020) classification, debtor information, visit details, etc. As part of registration, the HMS² system interfaces with credit bureaus and medical aids using electronic data interface (EDI) technology with a switching provider (MediKredit, n.d.). The EDI services allow for credit checks on a patient to confirm address details, contact information, income, and the record status on the Home Affairs database, which indicates whether the patient is, for instance, alive. Simultaneously, the patient's SA ID (Identification Document) number is used to verify their medical aid status, including whether the member's medical aid is active and if funds are available. This process is automated and integrated, eliminating the need for operators to use multiple systems and creating a seamless experience (Wagner, 2020).

During this process, the patient also signs the visit/admission form, granting permission for services rendered and accepting responsibility for account settlement where applicable. Figure 2-5 is an example of the service options page in the HMS^2. Patient registration details, visit information and any accompanying documentation scanned and attached to the patient's record are entered into the patient's shared medical record.

This process establishes a comprehensive and longitudinal view of the patient, making it instantly accessible to any other healthcare facility utilising the HMS² system. Healthcare facilities can seamlessly track the patient's journey within and across different healthcare settings through this interconnected approach (ECDoH, 2023). This sharing of medical records enhances the continuity of care, ensures a more holistic understanding of the patient's medical history, and contributes to collaborative and informed decision-making across the healthcare network (Wagner, 2020). Patient labels are generated and affixed to the patient manual folder, streamlining additional service requests to National Health Laboratory Services (NHLS) and South African National Blood Services (SANBS). This process saves time for clinical staff, eliminating the need to fill out request forms manually and ensuring consistency in patient details. All forms and labels are barcoded. Simultaneously, an automated account is opened and immediately accessible to the revenue module for revenue collection (Wagner, 2020). The registration process also facilitates the collection of funds, with receipts printed for documentation purposes.

2.3.2.2 Outpatient Module

The Outpatient Department (OPD) module is a comprehensive tool for clinics or outpatient departments at a facility level. It facilitates the booking of appointments, electronic check-in of patients, and various functionalities aligned with the South African National Data Indicator Set (NIDS) and other relevant data elements (NDoH, 2019b). This module empowers clinical staff to record routine data adhering to standardised data sets.

Moreover, the OPD module offers functionality for clinical staff to document clinical notes, capture vital signs, record OPD consultation reports, initiate patient admissions, confirm bed availability, request clinical support services, seek digital radiology services, generate electronic prescriptions, and attach any additional documentation to the patient's visit (Wagner, 2020). Integration with external service providers, i.e., NHLS, allows the end-user easy access to previously requested laboratory tests, which mitigates the duplication of tests and improves both quality of care and cost efficiencies (ECDoH, 2023). The module also has reporting features tailored for operational and management purposes, providing valuable insights into the OPD operations (Wagner, 2020). Notably, the details of OPD visits are recorded in the patient's medical record and accessible to authorised users across all the facilities at any level within the digital ecosystem. This integration ensures a unified patient record, enhancing continuity of care and facilitating informed decision-making across healthcare providers (Wagner, 2020). Figure 2-6 is an example of the outpatient department.

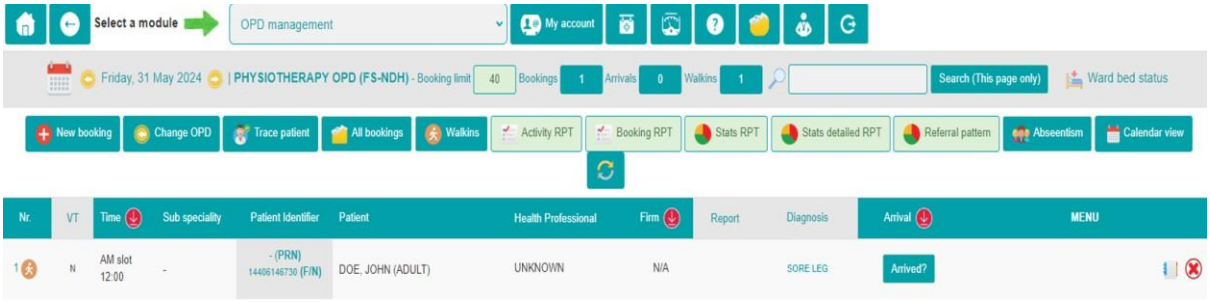

Figure 2-6: Outpatient Department (The Researchers)

2.3.2.3 Ward Module

The ward or inpatient module serves as a comprehensive system for the electronic admission, internal transfer, and separation of patients within a healthcare facility. This module encompasses various functionalities, including recording the National Indicator Data Set (NIDS) data and other necessary data elements (Wagner, 2020). In addition, the ward module empowers clinical staff by providing functionality for documenting clinical notes, capturing vital signs, recording ward discharge summaries, requesting clinical support services, seeking digital radiology services, generating electronic prescriptions, requesting meals from the kitchen, and attaching any additional documentation to the patient's record (NDoH, 2020).

Records still require printing and signing as the use of digital signatures at the time of the study was still being explored. The module also has reporting features tailored for operational and management purposes, offering valuable insights into the facility's healthcare operations (Wagner, 2020). Figure 2-7 is an example of the Ward module.

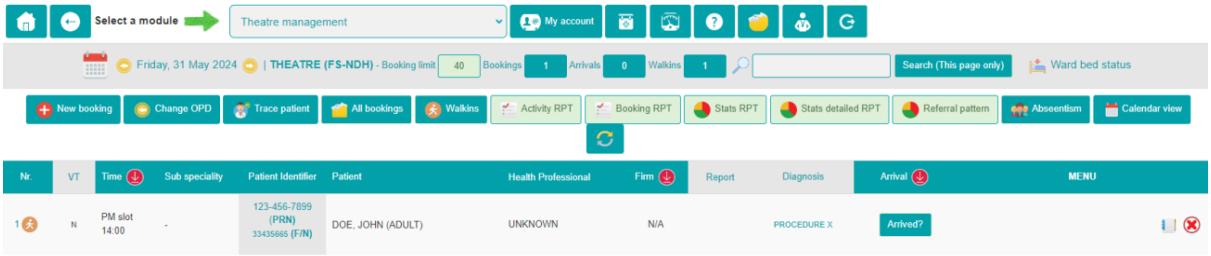

Figure 2-7: Ward/Inpatient management (The researchers)

Crucially, patient details are systematically recorded in the patient's medical record, ensuring accessibility for authorised users. This integration establishes a unified patient record, promoting continuity of care and facilitating informed decision-making across healthcare providers (NDoH, 2020). The ward module further enhances operational efficiency by offering routine reports for both operational and management purposes. These reports include midnight census reports, handover- and efficiency reports, daily ward reports, improved bed management and more. When utilised effectively, the module has the potential to replace manual ward registers entirely, with

reports accessible through a simple click (ECDoH, 2023). The system also allows for the aggregation and disaggregation of statistical information, providing both summarised and detailed insights at the patient level.

2.3.3 Theatre Slates Module

While currently possessing basic functionalities, it enables streamlining activities through theatre slates. The benefits include but are not limited to the accurate capturing of patient information and pre-operative planning (i.e. scheduling of operations). The module extends its capabilities by facilitating NIDS data collection and recording patient notes, service requests, and other relevant information (Wagner, 2020). Anticipating the evolving needs of healthcare management, the Eastern Cape Department of Health has outlined plans to enhance this module significantly during the 2024/2025 financial year (ECDoH, 2023). This expansion aims to incorporate comprehensive functionalities, ensuring a more robust and feature-rich system to support the intricacies of theatre operations. Figure 2-8 illustrates the theatre slate module.

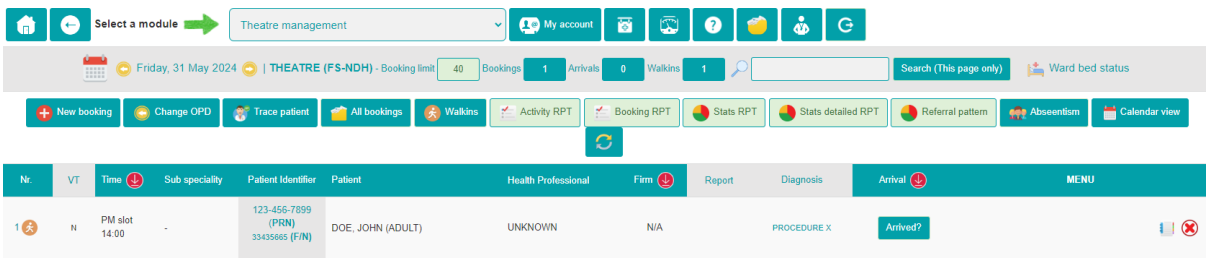

Figure 2-8: Theatre Slate example (The researchers)

2.3.3.1 Revenue Module

The revenue module is a pivotal component that seamlessly integrates various modules within the system. It adeptly receives electronic data from patient registration, outpatient visits, and inpatient wards, automatically incorporating this information into the patient's invoice linked to the patient account. A primary function of this module is the automated creation of invoices, effectively streamlining the billing process for services rendered (ECDoH, 2023). The module adheres to the UPFS coding standard (WCDoH, 2020), complemented by ICD coding for accuracy and precision.

Figure 2-9 provides an example of a patient account.

Figure 2-9: Patient account example (The researchers)

The Patient Revenue Management system encompasses several key functions (ECDoH, 2023):

- Electronic Data Interface Services: This encompasses the capability to perform credit checks, verify medical aid status, submit electronic claims to medical aids, and receive electronic remittance advice, all of which facilitate the efficient crediting of a patient's account.
- Billing and Invoicing: The system generates accurate and detailed invoices, ensuring transparency and accountability in the billing process for patient services.
- Charge Capture: It captures charges associated with specific medical procedures, tests, medications, or other healthcare services, facilitating precise billing and reimbursement.
- Medical Aid Processing: The module manages the processing of insurance claims, ensuring compliance with regulatory requirements and facilitating timely reimbursement from insurance providers.
- Payment Processing: Patient payments, received through various methods, are efficiently processed and recorded within the system.
- Revenue Analytics: The system provides analytics and reporting tools, enabling healthcare organisations to track and analyse revenue trends for informed financial planning and optimisation.
- Financial Reporting: Comprehensive financial reports are generated, offering insights into revenue streams, outstanding balances, and overall financial performance.
- Compliance Management: The module ensures compliance with billing and coding regulations, reducing the risk of errors and mitigating potential legal and financial consequences.
- Patient Statements: Patient statements are generated, detailing services provided, associated costs, and outstanding balances, enhancing transparency and communication.

- Refund Processing: Efficient processing of refunds, when necessary, is managed within the module to maintain accuracy and compliance with refund policies.

The Revenue Module significantly contributes to efficiently managing patient revenue by incorporating these functions.

2.3.3.2 PAIA Module

The PAIA Module is a tool designed to facilitate the electronic capture of requests for information and the comprehensive management of these requests through various stages, which may extend to potential medico-legal claims. This module aligns with the South African Promotion of Access to Information Act (RSA, 2000), ensuring strict compliance with regulatory requirements.

Key features of the PAIA Module include:

- Request Lifecycle Management: The module efficiently manages the entire lifecycle of requests for information, from initiation to resolution, with the flexibility to handle diverse scenarios, including potential medico-legal claims.
- Compliance with PAIA Guidelines: Adhering to the South African PAIA guidelines, the module ensures that processes align with the legal framework governing access to information.
- Document Scanning and Linking: It provides the functionality to scan documents and links, enabling the attachment of relevant documents to the request. This feature enhances the completeness and accuracy of information associated with each request.
- Integration with Patient Medical Records: The PAIA module is seamlessly integrated with the HMS² patient records. When a patient's medical record exists, the request is intelligently linked to ensure a holistic view of the patient's information.
- Routine Operational and Management Reports: The module offers a range of routine operational and management reports. These reports, supported by real-time data analytics, provide insights into the status and trends of requests for information across financial years, healthcare facilities, and clinical domains.

Figure 2-10 is an example of a PAIA request.

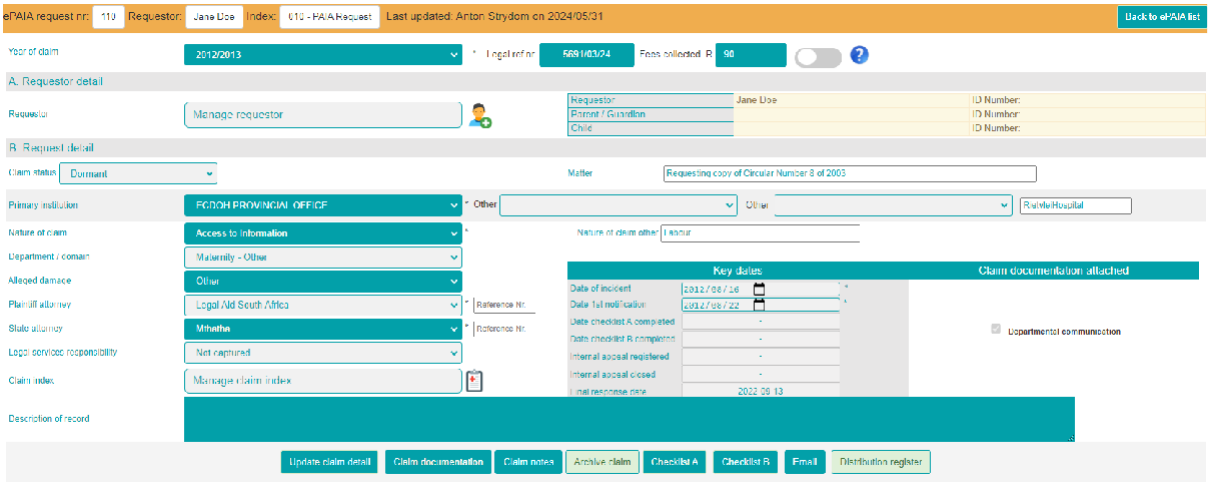

Figure 2-10: PAIA request example (The researchers)

2.3.3.3 Medico-Legal Claims Management Module

This module is a comprehensive system for the electronic capture and recording of medico-legal claims against the Eastern Cape Department of Health. It provides robust functionalities for the complete management of each claim, spanning from the initial letter of demand through to finalisation (ECDoH, 2023).

Key features of the Medico-Legal Claims Management module include (Wagner, 2020):

- Claims Lifecycle Management: The module facilitates the entire lifecycle of medico-legal claims, offering tools for the systematic and organised management of each claim from inception to resolution.
- Documentary Record Keeping: It enables the electronic capture and meticulous recording of relevant documentation associated with each medico-legal claim. This feature ensures a comprehensive and accurate repository of information.
- Claim Resolution Workflow: The module supports a structured workflow for managing claims, guiding the process from receiving a letter of demand to finalising the claim. This ensures transparency and efficiency in the resolution process.
- Routine Operational and Management Reports: The module offers a diverse range of routine operational and management reports. These reports, enhanced by real-time data analytics, provide valuable insights into the status and trends of claims. Parameters for analysis include financial years, healthcare facilities, claim indexing, nature of the claim, alleged damages, clinical domains, and more.

2.3.4 Additional Modules

In addition to the core modules, several auxiliary modules contribute to the system's comprehensive functionality. These are (Wagner, 2020):

- Clinical Support Service Requests: This module is seamlessly integrated with all clinical modules, including the Outpatient Department (OPD) and ward modules, enabling healthcare providers to electronically request various clinical support services. This functionality streamlines the process of seeking and coordinating additional support services as needed for patient care.
- Digital Radiology: The system includes a dedicated module for digital radiology services. This module facilitates the seamless integration and management of digital imaging requests, enhancing diagnostic capabilities and improving the overall efficiency of radiological services. The facility picture archiving system (PACS) is still used to view patient radiology scans.
- Electronic Prescriptions (e-Scripts): The Electronic Prescriptions module allows healthcare professionals to generate electronic prescriptions as informed by approved medicine formularies. This feature enhances the accuracy of prescription information and contributes to the modernisation of the prescription process. At the time of the study, the script could be generated on HMS², printed and signed to allow the pharmacy to dispense medication. The system development team of the Eastern Cape Department of Health is exploring the use of electronic signatures.
- Data Collection Templates: The system allows creating customisable data collection templates or electronic tick registers. These templates can be easily linked to various reporting units, accommodating the National Indicator Data Set (NIDS) and additional data requirements at provincial and facility levels. This flexibility ensures data collection aligns with specific reporting needs and regulatory standards.
- Digitisation of old patient records: The system facilitates scanning and linking old patient records to the corresponding patient electronic folder. This functionality allows for the integration of historical patient information into the digital environment. When an old patient record is scanned, it is electronically linked to the respective patient folder, ensuring a comprehensive and consolidated view of the patient's medical history. This feature preserves legacy patient data and enhances the efficiency of accessing and managing historical records, contributing to a more complete and integrated patient care experience within the digital framework.

2.4 Strategy Overview

As part of the Eastern Cape Department of Health's strategic focus (ECDoH, 2020), a Health Turnaround Strategy has been developed and is being implemented. The primary objective of the Health Turnaround Strategy is to navigate the Eastern Cape public healthcare system towards a re-

engineered sustainable service platform. This platform is envisioned to move from a primarily paper-based environment to a "less paper" environment using technology to digitally enable our healthcare facilities and become a more data-driven organisation.

The strategy aims to achieve this overarching goal through three foundational layers (ECDoH, 2020):

- Institutionalising Performance Reporting and Management Systems: Implementing robust performance reporting and management systems to ensure transparency, accountability, and continuous improvement across all levels of our organisation.
- Progressive Change Management, Stakeholder Engagement, and Strategic Marketing and Communication: Undertaking strategic change management initiatives, engaging stakeholders effectively, and employing targeted marketing and communication strategies to enhance awareness and understanding of our evolving health system.
- Special Focus: In alignment with the Eastern Cape Department of Health's commitment to inclusivity and equitable healthcare, the Eastern Cape Department of Health are significantly emphasising improving access to healthcare for marginalised groups. This commitment underscores the ECDoH's dedication to fostering a healthcare environment that is accessible to all, irrespective of social or demographic factors.

The eHealth project stands as one initiative aligning with the strategic goals of the Eastern Cape Department of Health by leveraging Information and Communication Technologies (ICTs) to revolutionise healthcare within the province.

2.5 Strategic Framework Overview

The eHealth project is anchored in a strategic framework aimed at reforming healthcare delivery by integrating innovative technologies. It is driven by the directive to enhance the quality of patient care and services, emphasising the seamless and secure flow of health information across the healthcare ecosystem (Wagner, 2020).

2.5.1 Key Components

The key components of this strategy involve eHealth governance, ICT integration, the Health Information System and Interoperability and integration.

- eHealth governance: Project governance is indispensable for ensuring the success of a project. In 2021, the Eastern Cape Department of Health recognised this importance and consequently established an eHealth steering committee. This committee plays a crucial role in coordinating the development and implementation of several eHealth-related projects, emphasising HMS² as a pivotal system within this framework. The committee operates under the direct oversight of the Head of Department and is composed of key business units within the ECDoH. These units span clinical and

non-clinical services, information management, risk management, and internal audit and enjoy interdepartmental support from entities such as the Eastern Cape Provincial Treasury and the Eastern Cape Office of the Premier. The collaborative nature of this committee ensures comprehensive oversight and expertise from various domains, thereby enhancing the efficacy of project management and facilitating the achievement of project goals.

- ICT Integration: The project revolves around the integration of robust ICT solutions tailored to collect, store, and exchange health information securely. This integration enables the creation of a unified platform for data management and analysis.
- Figure 2-11 illustrates governance in the ECDoH.

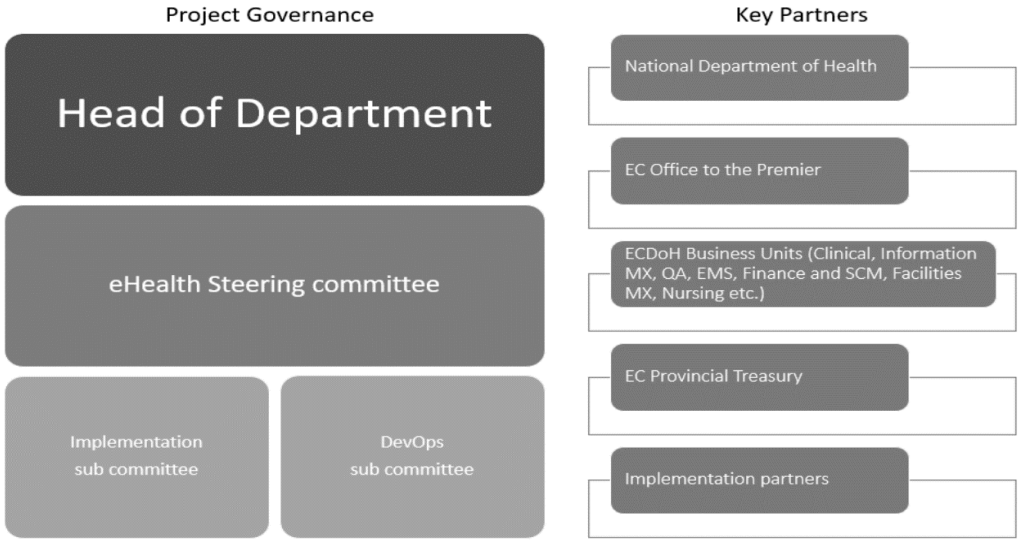

Figure 2-11: Eastern Cape Department of Health eHealth governance (ECDoH, 2023)

- Health Information System: A central component of the project, this system aims to facilitate the improved collection, storage, and management of health data. It supports consolidating patient records, enabling healthcare professionals to access accurate and timely information crucial for informed decision-making.
- Interoperability and Integration: The eHealth systems prioritise interoperability, ensuring seamless communication between disparate healthcare entities. This integration fosters better coordination among healthcare providers, improving patient outcomes and a more cohesive healthcare system.

2.5.2 Primary Goals and Objectives

The following are the goals and objectives of the strategic framework (ECDoH, 2023):

- Enhanced Patient Care: The primary goal is to elevate the quality of patient care by enabling healthcare providers to access comprehensive and up-to-date health information. This

accessibility leads to more informed diagnoses, personalised treatment plans, and improved patient outcomes.

- Optimised Service Delivery: The project aims to streamline healthcare service delivery by reducing redundancies, improving efficiency and quality of care and minimising errors through standardised and centralised health information management.
- Healthcare Reform and Improvement: By leveraging eHealth systems, the project endeavours to contribute to broader healthcare reform efforts within the Eastern Cape Department of Health. It seeks to modernise healthcare practices, enhancing the overall effectiveness and responsiveness of the healthcare system.
- Modern ICT infrastructure and improved broadband connectivity: Modernise and enhance the ICT infrastructure of targeted healthcare facilities by replacing outdated and dilapidated systems with new technology, ensuring robust Local Area Network (LAN) and improved Wide Area Network (WAN) connectivity to support efficient and secure data communication and management.
- Data Security and Privacy: Ensuring the confidentiality, integrity, and availability of health information remains a core objective. The project is committed to implementing robust security measures to safeguard sensitive health data against breaches or unauthorised access. The eHealth project embodies a strategic vision to leverage technological advancements to revolutionise healthcare delivery. Focusing on information integration, interoperability, and improved healthcare outcomes aligns closely with the overarching objectives of the ECDoH's healthcare reform agenda.

2.6 HMS² Aligning with the South African HNSF, Digital Health Strategy and Digital Health Ecosystem

The alignment of the HMS² system with the South African Digital Health Ecosystem, Health Normative Standards Framework, and the country's digital eHealth strategy and NHI is pivotal in ensuring cohesive, interoperable, and impactful healthcare transformation. This section provides a detailed overview of this alignment based on the data collected through interviews with the ECDoH stakeholders and department officials. After the thematic analysis, their views, opinions and perspectives are summarised and consolidated in the subsections below.

2.6.1 The South African Digital Health Ecosystem

The HMS² system can play an important role within the Digital Health Ecosystem of South Africa by:

- Interoperability: The system is designed to integrate with other digital health solutions and systems, enabling data exchange and collaboration among various healthcare entities. It conforms to interoperability standards, allowing for the sharing of patient information across facilities and regions, fostering a connected healthcare landscape.

- Data Governance and Security: Aligning with the ecosystem's emphasis on data governance, the HMS² system prioritises robust security measures and adherence to privacy regulations. It strives to ensure the integrity, confidentiality, and availability of health information.
- Scalability and Adaptability: The system's architecture is designed to evolve with technological advancements and changing healthcare needs. Its scalability allows for future expansion and adaptation, aligning with the ecosystem's goal of sustainable and adaptable digital health solutions.

2.6.2 South African Health Normative Standards Framework

The HMS² EMR system aligns with the Health Normative Standards Framework (NDoH, 2020) by:

- Data Standardisation: It adheres to national standards for health information systems, ensuring that data elements, coding structures, and terminology used within the system align with the standardised framework. This conformity facilitates consistency, comparability, and accuracy of health data.
- Comprehensive Health Records: The HMS² system captures and maintains health records following the framework's guidelines. It encompasses patient demographics, medical history, treatment plans, and diagnostic information, contributing to comprehensive patient-centric care.

2.6.3 South African Digital Health Strategy

The HMS² EMR system aligns with the South African Digital Health Strategy (NDoH, 2019) relating to:

- Strategic Objectives: It supports the strategic objectives outlined in the eHealth strategy, such as improving access to healthcare services, enhancing healthcare quality, and enabling data-driven decision-making. The system facilitates efficient information sharing.
- Collaborative Healthcare Delivery: By fostering collaboration among healthcare stakeholders, the HMS² system embodies the strategy's vision of integrated care delivery. It promotes multidisciplinary collaboration, enabling coordinated care and improving the patient experience.
- Empowerment Through Technology: The system empowers healthcare providers with technology-driven tools and insights, aligning with the strategy's focus on leveraging technology to enhance healthcare delivery. It enables evidence-based decision-making, resource optimisation, and improved patient engagement.

The HMS² system's alignment with the South African Digital Health Ecosystem, Health Normative Standards Framework, and eHealth Strategy underscore its role in supporting the country's digital healthcare transformation.

2.7 Implementation and Execution

The feedback from the department officials indicated that the absence of robust eHealth systems within healthcare facilities in the ECDoH has posed multifaceted challenges, ranging from patient record management issues to operational inefficiencies. According to a departmental official, these challenges encompass "*poor patient identification, the loss of records and or the duplication thereof, prolonged waiting times, inadequate clinical documentation, extended lengths of in-patient hospital stay, high bed utilisation rates, and insufficient real-time data for decision-making."*

As a department official indicated, "such deficiencies impact patient care and lead to financial repercussions, increased litigation, and compromised incident management within hospitals. Before delving further into the ECDoH's eHealth journey, it is imperative to address foundational elements." This involves a strategic financial investment in ICT infrastructure, necessitating robust maintenance for sustainability. The primary focus of this investment is directed towards ICT infrastructure and human resources, laying the groundwork for the successful implementation and long-term viability of eHealth initiatives.

2.7.1 Building the Digital Health Ecosystem

Building a robust digital health ecosystem is crucial for enhancing patient care, improving efficiency, and fostering collaboration among various healthcare entities (Wagner, 2020). The HMS² system plays a pivotal role in this ecosystem. It utilises the HNSF to seamlessly integrate with diverse systems within the digital health landscape. The HNSF (2021) is the backbone, facilitating interoperability and communication between different healthcare components. In the context of HMS², integration with key systems like HPRS, NHLS, Electronic Data Interchange (EDI) services, and cutting-edge health technology solutions such as digital radiology and Cardiotocography (CTG) is essential.

HPRS integration allows for the move towards using the HPRN as the patient's unique patient identifier across the continuum of care. This streamlines healthcare delivery and enhances the quality of care by providing healthcare providers with a holistic understanding

of the patient's health journey. NHLS integration ensures that laboratory results are seamlessly incorporated into the patient's record, facilitating quick and accurate diagnosis and treatment decisions. EDI services play a vital role in the secure exchange of healthcare information for electronic claims submission and improved efficiencies with revenue management. Moreover, HMS²'s integration with advanced health technology solutions like digital radiology and CTG enhances diagnostic capabilities.

These technologies enable the generation of high-quality imaging and monitoring data, which, when integrated into the EMR/EHR, contributes to a more comprehensive and real-time patient record. By leveraging the HNSF to integrate with these diverse systems, HMS² fosters

collaboration and data exchange, resulting in a more cohesive digital health ecosystem. This interconnected environment enables healthcare providers to make informed decisions, reduces redundancies, and ultimately improves patient outcomes. Additionally, seamless information sharing within the digital health ecosystem promotes efficiency, reduces errors, and enhances healthcare delivery. This is explained in Figure 2-12.

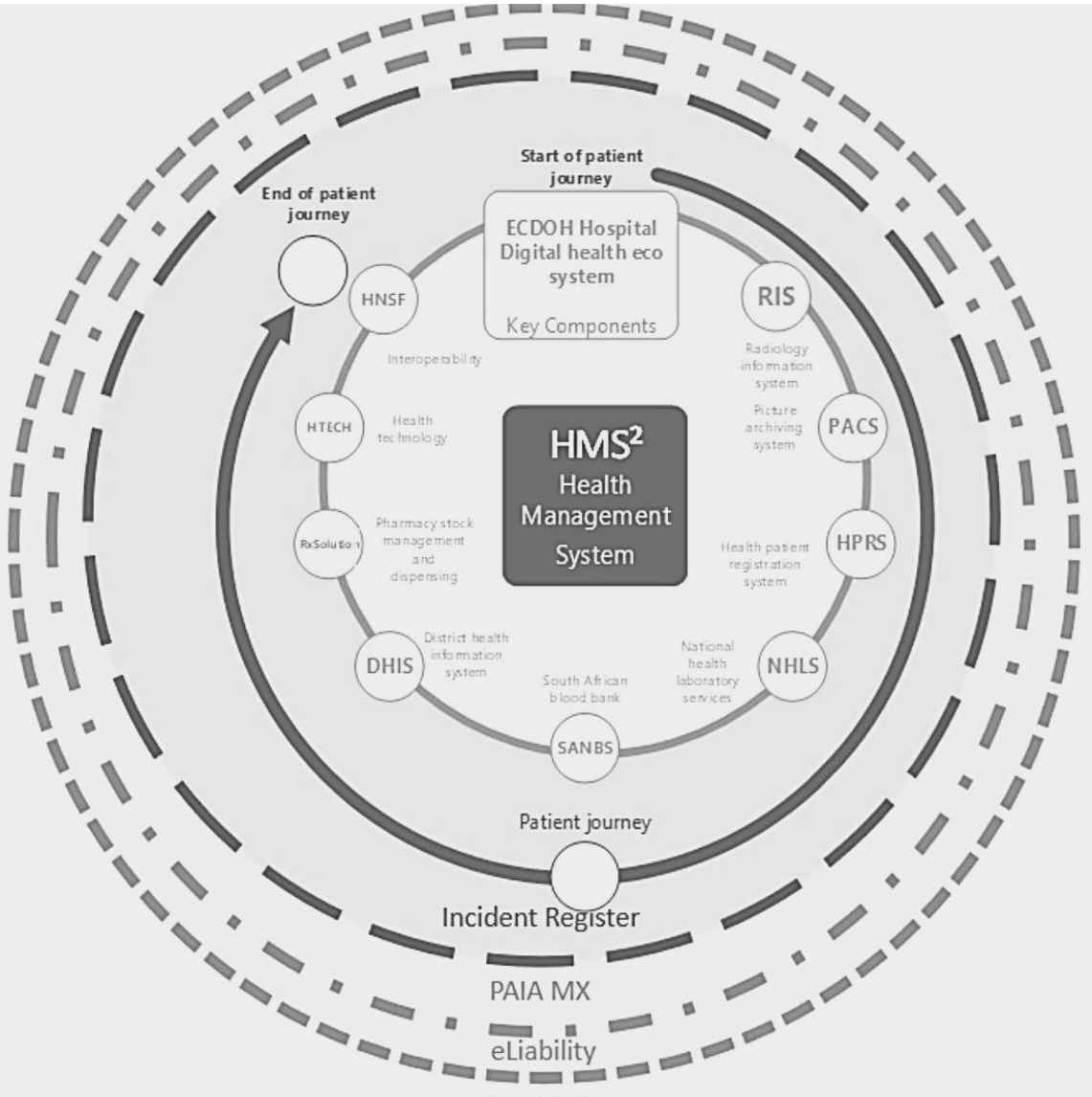

Figure 2-12: The ECDoH High-level Digital Health Ecosystem (ECDoH, 2023)

2.8 Critical eHealth Building Blocks

The data, coding and themes found after thematic analysis was applied indicated that the cornerstone of successful eHealth implementation rests upon several crucial factors. These are explained below.

2.8.1 Requirements Analysis

Identify and analyse the specific clinical and administrative needs of healthcare providers. "*This includes understanding workflows, data requirements, and compliance standards"* (Department official).

2.8.2 ICT Infrastructure

The backbone of eHealth systems requires reliable networks, up-to-date computer equipment, and peripheral devices. Additionally, effective ICT support for infrastructure and system monitoring is imperative. However, a department official indicated that "*numerous healthcare facilities within the ECDoH face challenges due to inadequate ICT infrastructure and outdated equipment, not to mention reliable and stable connectivity*." This deficit results in reactive, rather than proactive, approaches to ICT solutions, adversely impacting critical clinical and administrative functions within the eHealth spectrum.

The HMS² system, a testament to more than a decade-long development endeavour, has emerged as a robust platform designed exclusively by the government for the government (ECDoH, 2020). From its inception, it was meticulously crafted as a proprietary asset of the ECDoH. As mentioned by a department official, "*the system and its intricately designed source code stand as a cornerstone of technological innovation, conceived and built from the ground up*." One of the defining attributes of the HMS² system lies in its ownership structure, positioning it squarely within the purview of the ECDoH. As indicated by a department official, "*this deliberate strategy not only underscores the system's alignment with governmental objectives but also yields substantial financial benefits for the Department*." By eschewing recurring software and licensing costs, the Department has realised significant savings, directing these financial resources towards strategic investments in ICT infrastructure. The dividends of this strategic approach are evident in the rejuvenation and modernisation of ICT infrastructure across various facilities that received the HMS² system. The Department's judicious allocation of savings has facilitated the seamless provisioning of new infrastructure while ensuring the timely replacement of obsolete and dilapidated infrastructure. In essence, the HMS² system serves as a technological cornerstone for the ECDoH. As proclaimed by a department official, "*HMS² embodies a fiscally responsible model, fostering a symbiotic relationship between technological innovation and prudent financial stewardship*."

2.8.3 Facilitating Connectivity in Healthcare: A Pillar of Digital Health Transformation

In the ever-evolving healthcare landscape, the seamless exchange of information among healthcare facilities is paramount for delivering efficient and patient-centric services. Within a digital health ecosystem, connectivity emerges as a linchpin that transforms how medical data is shared and leveraged across the healthcare continuum. At the forefront of this paradigm shift is integrating shared patient medical records. This catalytic element promotes continuity of care and gives healthcare providers comprehensive insights into a patient's health history. Notably, the ECDoH, in its pursuit of innovation, has forged strategic partnerships with key stakeholders, including the Eastern Cape Office of the Premier. This collaborative effort is instrumental in advancing the implementation of broadband infrastructure across healthcare facilities, a move designed to facilitate seamless inter-facility communication.

The Eastern Cape Office of the Premier, working hand in hand with the ECDoH, plays a crucial role in steering the implementation of broadband connectivity. This concerted effort addresses the immediate need for enhanced communication among healthcare facilities and lays the foundation for a future-ready digital health ecosystem. As indicated by a department official, "*establishing robust connectivity infrastructure fosters real-time sharing of patient medical records, enabling healthcare professionals to make informed decisions promptly and resulting in improved patient outcomes*."

Furthermore, implementing broadband connectivity enhances telemedicine capabilities, unlocking the potential for remote consultations and virtual health services. Patients in remote or underserved areas gain unprecedented access to healthcare expertise, bridging geographical gaps and ensuring equitable healthcare delivery. As indicated by an ECDoH stakeholder, "*the collaboration between the Eastern Cape Department of Health and the Office of the Premier is a testament to the commitment to leveraging technology to improve healthcare services*." Establishing a robust digital infrastructure enhances connectivity within the healthcare sector. It paves the way for a more resilient and responsive healthcare system, benefiting healthcare providers and their communities.

2.8.4 Interoperability and Data Exchange

Interoperability standards are crucial in ensuring seamless communication and data exchange between different systems within the healthcare landscape (Chuma & Sibiya, 2022).

2.8.4.1 South African Health Normative Standards Framework

In this context, the HNSF is a foundational guideline for achieving interoperability in the South African digital health ecosystem. The SA HNSF (2021) is designed to establish a common ground for healthcare information exchange in South Africa. It defines standardised data formats, communication protocols, and terminology to facilitate interoperability among diverse healthcare systems (NDoH, 2021). By adhering to these norms, healthcare providers, software developers,

and other stakeholders can ensure their systems exchange information consistently and standardised.

2.8.4.2 Open-Source Technologies and Integration

Open-source technologies can play a pivotal role in achieving interoperability by providing flexible and customisable solutions. Leveraging open-source systems such as Mirth as an integration engine exemplifies this approach. Mirth is an open-source, cross-platform integration engine that enables the seamless exchange of health information across disparate systems (NextGen Healthcare, 2024). Mirth, also known as Nextgen is an open-source integration engine that facilitates the exchange of health information by translating and routing data between different systems. It supports various healthcare data standards, including HL7 and IHE profiles. Using Mirth allows for integrating different systems within the digital health ecosystem, such as HMS² and others (NextGen Healthcare, 2024). This integration can take various forms:

- Data Exchange: Mirth can be configured to translate and exchange patient data between HMS² and any other 3rd party systems, using standardised formats like HL7, ensuring consistency and accuracy.
- Workflow Integration: Mirth can be customised to align with specific clinical workflows, ensuring that data seamlessly moves between systems without disrupting established processes.
- Real-time Communication: Mirth supports real-time data exchange, enabling timely sharing of critical information between systems and ultimately improving patient care and decision-making.

The benefits of using integration engines include, for instance (as indicated by a department official):

- Reduced Data Silos: Integration breaks down data silos, ensuring that patient information is accessible across different systems, promoting a holistic view of patient health.
- Efficiency: Automated data exchange streamlines workflows, reducing manual data entry and the likelihood of errors.
- Scalability: Open-source solutions like Mirth are scalable, adapting to the evolving needs of healthcare ecosystems as they grow.

2.8.4.3 Security and Privacy Measures

Implement robust security measures to protect patient information. This includes access controls, encryption, audit logs, and compliance with healthcare data protection regulations (HIPAA, n.d.).

2.8.4.4 User Training

Provide comprehensive training programs for healthcare professionals and support staff. As a department official indicated, "*users should be ensured that they are proficient in using the EHR system to maximise its benefits and minimise errors*."

2.8.4.5 Change Management

Develop a change management plan to address the cultural and organisational shifts associated with adopting a new EMR/EHR system. Communicate changes effectively and provide ongoing support to manage resistance.

2.8.4.6 Customisation and Configuration

In the ever-evolving landscape of healthcare technology, the customisation and configuration of eHealth systems play a pivotal role in ensuring that digital solutions meet the dynamic needs of healthcare providers and end users. Integrating an agile methodology and establishing a dedicated DevOps subcommittee within the eHealth steering committee have become instrumental in achieving continuous system development and enhancements. As indicated by a department official,

> *recognising the need to align the eHealth system with the ever-changing healthcare industry demands, the eHealth steering committee took a strategic leap by forming a specialised DevOps subcommittee. This subcommittee is tasked with orchestrating the continual development and enhancement of the eHealth system, focusing on the seamless integration of technology and the unique requirements of clinical and non-clinical end users. One of the primary goals of this DevOps subcommittee is to foster collaboration between technical experts and healthcare professionals.*

By working closely with clinical and non-clinical end users, the committee ensures that the eHealth system is technologically robust and aligns with healthcare providers' practical needs and workflows. This collaboration serves as a vital feedback loop, allowing for the identification of user-specific requirements and the implementation of tailored solutions.

Adopting an agile methodology further amplifies the responsiveness of the eHealth system to the rapidly changing landscape of healthcare. Agile practices, such as iterative development, frequent testing, and continuous feedback loops, enable the system to evolve in tandem with emerging business demands. This approach facilitates quick adaptation to new clinical protocols, regulatory changes, and advancements in healthcare practices. As indicated by a department official, "t*he customisation and configuration processes are intricately woven into the DevOps pipeline, allowing for seamless integration of updates, patches, and new features. This ensures the system's*

reliability and minimises disruptions to ongoing healthcare operations." The agility provided by the DevOps subcommittee and the agile methodology is a cornerstone in addressing the challenges posed by the ever-shifting healthcare landscape.

In conclusion, the eHealth steering committee's strategic decision to establish a DevOps subcommittee and adopt an agile methodology underscored the commitment to providing a dynamic and user-centric eHealth system. The synergy between technical experts, healthcare professionals, and agile practices ensured that the customisation and configuration processes remain responsive to the evolving needs of the healthcare industry, ultimately enhancing the effectiveness and efficiency of healthcare delivery.

2.8.4.7 Quality Assurance and Testing

In the dynamic landscape of eHealth, where the reliability and performance of systems directly impact patient care, quality assurance (QA) and testing processes have become pivotal. The eHealth steering committee's strategic move to establish a DevOps subcommittee has facilitated a holistic approach to quality assurance, fostering close collaboration between the DevOps testing team and end users. This collaborative effort ensures that the eHealth system meets technical requirements and aligns with healthcare professionals' diverse needs. As indicated by a department official,

> *the DevOps subcommittee plays a central role in bridging the gap between development and testing teams, facilitating a continuous feedback loop crucial for maintaining the quality of the eHealth system. This collaboration is grounded in the understanding that effective testing is not just about identifying and fixing bugs but also about ensuring that the system aligns with the ever-evolving business requirements of the healthcare industry.*

A special testing platform has been implemented within the system's framework to simulate real-life scenarios as closely as possible. This platform allows the testing team to create scenarios replicating healthcare environments' complexities, providing a comprehensive understanding of how the system performs under various conditions. By closely involving end users in the testing process, the eHealth system undergoes scrutiny from those who interact directly with it, offering valuable insights into user experience and usability. The collaboration extends beyond traditional testing phases, with end users actively participating in user acceptance testing (UAT). As indicated by a department official,

> *this involvement not only validates the technical functionality of the system but also ensures that it aligns with the workflow and preferences of healthcare professionals. The feedback garnered during UAT becomes an integral part of the iterative development process, contributing to the refinement of features and enhancing the overall user experience.*

A special testing platform is a cornerstone in the eHealth system's journey towards quality assurance excellence. This platform empowers the DevOps testing team to create realistic simulations, enabling them to identify potential issues before deployment and ensuring a smoother user experience in real-world scenarios.

In conclusion, the collaboration between the DevOps subcommittee, testing team, and end users in quality assurance and testing is pivotal for building robust eHealth systems. The eHealth system meets technical specifications by actively involving end users in testing and implementing a specialised testing platform. It aligns closely with the business and user requirements, ultimately enhancing the quality of healthcare delivery. This collaborative approach fosters a culture of continuous improvement and adaptability, ensuring that the eHealth system remains at the forefront of technological and healthcare advancements.

2.8.4.8 Compliance and Regulation

The eHealth steering committee is persistently championing efforts to ensure compliance with software development standards and the intricate tapestry of the South African legislative framework. Recognising the critical importance of compliance, the eHealth steering committee has implemented a multifaceted approach to align the eHealth system with the regulatory landscape of South Africa. This involves an ongoing commitment to staying abreast of changes in legislation, standards, and industry practices, ensuring that the eHealth system remains at the forefront of compliance.

The eHealth steering committee has adopted a proactive stance, integrating compliance considerations into every phase of the software development lifecycle. Compliance remains a central focus from the initial design and development stages to testing, deployment, and ongoing system maintenance. This holistic approach ensured that the eHealth system met current standards and was well-positioned to evolve in tandem with the regulatory landscape. The eHealth steering committee acknowledged that compliance was not a static goal but a dynamic state that requires constant vigilance and adaptation. Regular audits, both internal and external, are conducted to assess and improve compliance levels. These audits serve as invaluable tools for identifying areas of improvement, refining processes, and ensuring that the eHealth system aligns seamlessly with the highest standards of quality and regulatory adherence. To fortify its commitment to compliance and risk management, the eHealth steering committee has expanded its purview to include key stakeholders who contribute invaluable expertise. To enhance compliance oversight and manage risks effectively, the committee has welcomed the Department Risk Officer, Internal Audit, and inter-departmental support from the Eastern Cape Provincial Treasury. As a department official indicates,

> *the Department Risk Officer brings specialised knowledge in risk assessment and mitigation, ensuring that the eHealth system adheres to regulatory requirements and addresses potential risks associated with its operation. Internal Audit, as a crucial component of the extended committee, contributes*

an independent and objective perspective, conducting thorough assessments to validate compliance and identify areas for improvement.

In conclusion, the eHealth steering committee's commitment to compliance and regulation is a testament to the unwavering dedication to delivering a secure, reliable, and legally compliant eHealth system. By establishing a dedicated subcommittee, integrating compliance throughout the development lifecycle, and embracing a proactive stance, the eHealth steering committee ensures that compliance is not a destination but an ongoing journey toward excellence.

Through continual efforts and a forward-looking approach, the eHealth system is poised to navigate the complex landscape of compliance and regulation, meeting the evolving needs of technology and healthcare standards.

2.8.4.9 Monitoring and Continuous Improvement

In eHealth, where technology and healthcare intersect, the journey doesn't end with system implementation; it evolves through vigilant monitoring and continuous improvement (Wagner, 2020). The eHealth steering committee has emerged as a proactive force in this ongoing process, dedicated to overseeing the implementation and usage of the system and driving relentless efforts for continuous enhancement, ensuring alignment with evolving business requirements. Monitoring is essential in the eHealth steering committee's strategy, providing real-time insights into system performance, user behaviour, and overall functionality. The committee keeps a watchful eye on key performance indicators, system availability, and user interactions. This proactive monitoring approach allows for the early identification of potential issues, paving the way for swift resolutions and minimising disruptions to healthcare operations. The eHealth steering committee's commitment to continuous improvement is ingrained in the organisational culture. Regular assessments and evaluations are conducted to gauge the system's efficacy in meeting business requirements. Feedback loops, comprising input from end users, healthcare professionals, and technical experts, serve as invaluable information sources for identifying improvement areas and streamlining functionality.

The eHealth steering committee has established a structured feedback mechanism to facilitate continuous improvement. End users at the forefront of system utilisation play an active role in providing insights and suggestions. This user-centric approach ensures that the eHealth system meets technical specifications and aligns seamlessly with healthcare providers' practical needs and workflows. This agile approach ensures adaptability to changing business requirements and fosters a culture of innovation and responsiveness. As indicated by a department official, "*a dedicated continuous improvement subcommittee within the eHealth steering committee spearheads initiatives to refine processes, enhance functionalities, and incorporate emerging technologies*." This subcommittee catalyses driving innovation, collaborating with development teams to explore new solutions and technologies that can further elevate the performance and capabilities of the eHealth system.

In conclusion, the eHealth steering committee's focus on monitoring and continuous improvement is a testament to its commitment to delivering a cutting-edge and user-centric eHealth system. By embracing real-time monitoring, fostering a culture of feedback, and leveraging agile methodologies, the committee ensures that the system meets current business requirements and is well-positioned to adapt to future challenges and advancements in healthcare technology. The eHealth system remains a cornerstone in pursuing excellence in digital healthcare delivery through this dynamic approach.

2.9 Adopting a Phased Implementation Strategy

The ECDoH has devised a phased approach to address the challenges of implementation. Phased implementation is crucial for successfully deploying eHealth systems as it allows for systematic and controlled integration of new technologies into existing healthcare workflows. As indicated by a department official, "*by breaking down the implementation process into manageable phases, Departments can identify and address challenges incrementally, reducing the risk of disruption to critical services*." This approach enables thorough testing, user training, and adaptation to the unique needs of different departments or facilities. Moreover, phased implementation facilitates real-time feedback and adjustments, ensuring that lessons learned from earlier stages inform subsequent rollouts. Ultimately, this thoughtful and gradual approach enhances the likelihood of a smooth transition, minimises potential setbacks, and promotes a more effective and sustainable adoption of eHealth systems across the healthcare ecosystem. The phased approach is further illustrated in Figure 2-13.

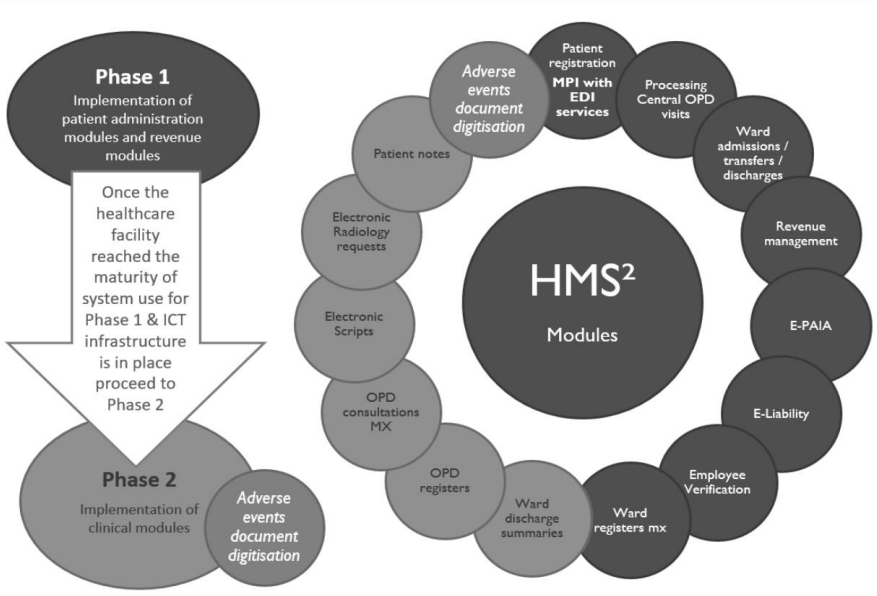

Figure 2-13: Phased implementation

2.9.1 Phase 1: Primary Deliverables

- The initial phase focuses on foundational elements and essential functionalities:

- Complete revamping of the healthcare facility's ICT, LAN, and WAN infrastructure to prepare it for onboarding the phase 1 modules.
- Integration with the HPRS and utilisation of Patient Reference Numbers (PRN) for unique patient identification.
- Establishment of a shared medical record for secure information exchange among healthcare facilities.
- Electronic patient registrations capture demographics, debtors' information, and compliance requirements.
- Implementation of electronic admissions, transfers, and separations alongside revenue management and claims processing.
- Deployment of a central register for patient visits and a management dashboard for critical facility records.
- Introduction of electronic PAIA requests and employee verification for streamlined operations.
- Implementation of a central medico-legal database to manage all claims against the Department.
- Provide Real-time data to a facility that received the HMS² system.

2.9.2 Phase 2: Modules Implementation

The subsequent phase focuses on clinical modules to enhance patient care and operational efficiency:

- ICT infrastructure: Revamping the ICT LAN and WAN infrastructure of the healthcare facility to prepare it for onboarding the phase 2 modules.
- Improved Patient Care: Real-time access to comprehensive patient information aids informed decision-making.
- Enhanced Efficiency: Automating clinical workflows reduces errors and saves time for healthcare workers.
- Enhanced Communication: Improved sharing of patient information among care teams ensures better coordination.
- Improved Data Accuracy: Reducing errors associated with paper-based records enhances patient safety.
- Advanced Analytics: Valuable data analytics tools facilitate improved insights for better healthcare delivery.

This phased approach ensures a structured and systematic deployment of eHealth solutions, addressing foundational requirements before advancing to more intricate clinical functionalities.

By addressing these challenges and adopting a strategic rollout plan, the ECDoH aims to improve healthcare delivery while optimising resources and improving patient outcomes.

2.10 Stakeholder Engagement

The stakeholder engagement within the ECDoH's eHealth initiative is a multifaceted and critical aspect that ensures strategic alignment, effective decision-making, and successful implementation of digital healthcare solutions. Here's a breakdown of the various stakeholders and their importance in this context (based on the data from the department officials):

2.10.1 Provincial eHealth Steering Committee

The committee ensures that eHealth strategies are aligned with provincial priorities and policies. It bridges administrative, financial, and healthcare expertise, fostering a holistic decision-making approach considering clinical needs and resource allocation.

2.10.2 Head of Department (HOD) and Executive Management Team (EMT):

The HOD and EMT provide the overarching strategic guidance and direction for the eHealth initiatives. They empower the eHealth Steering Committee to execute decisions and ensure alignment with the department's vision and goals.

Importance: Their leadership ensures that eHealth projects align with the department's strategic objectives. They oversee the implementation progress, enabling timely interventions and resource allocations as needed.

2.10.3 Healthcare Facilities and Personnel:

Frontline healthcare facilities and personnel are crucial stakeholders in successfully adopting and utilising the HMS² and other eHealth solutions. Their active involvement in the implementation process is vital for seamless integration into daily workflows.

Importance: Healthcare providers' engagement ensures that eHealth solutions meet the practical needs of patient care. Their input on usability, functionality, and workflow integration is invaluable for successful deployment.

2.10.4 Stakeholder Collaboration:

Engaging other key stakeholders, including external healthcare providers, technology vendors, community representatives, and regulatory bodies, is essential for a comprehensive and inclusive approach.

Importance: Collaboration fosters a shared understanding of the goals and benefits of eHealth initiatives. It facilitates the exchange of best practices, promotes innovation, and ensures that solutions align with regulatory requirements and community needs.

2.11 Outcomes and Impact

The researchers are optimistic about the continued positive impact of the Health Turnaround Strategy and the HMS² system. The outcomes and impact of the ECDoH eHealth steering committee's initiatives since the inception of the project in September 2021 are indicative of a transformative journey in healthcare management and service delivery. The successful implementation of the HMS² Phase 1 modules across 39 hospitals in the Eastern Cape as of 25 June 2024, spanning from the prestigious Nelson Mandela Academic Central Hospital to various Tertiary/Academic, Regional, District, and Specialised Hospitals, marks a significant milestone in strengthening patient administration and revenue management and putting in place the essential building blocks to proceed to HMS² phase 2 modules implementations (see Figure 2-14). The HMS² phase 1 modules were also implemented in 11 Free State Department of Health district hospitals. To broaden the scope and impact of the eHealth initiatives, HMS² Phase 1 modules were extended as part of a pilot to include three Emergency Medical Services (EMS) centres with a primary focus on patient administration and revenue management. This expansion reflects the commitment to optimising patient care beyond hospital settings, incorporating emergency services into the comprehensive eHealth framework. As part of a pioneering pilot project, the eHealth steering committee introduced automated electronic registers in three Community Health Centers (CHCs) and six Primary Health Care (PHC) facilities as part of a pilot project. This innovative

endeavour is a testament to the eHealth steering committee's forward-thinking approach and dedication to exploring new avenues for enhanced healthcare management.

In the 2024/2025 financial year, the Department plans to roll out the HMS² Phase 2 modules to 8 of the largest hospitals, and the Department plans to continue with Phase 2 during the MTEF period 2024/2025 to 2026/2027 (ECNoH, 2023). This strategic expansion demonstrates the system's robustness and emphasises a phased and well-thought-out approach to implementation, ensuring operational efficacy.

As an integral aspect of system implementation, the comprehensive overhaul of Information and Communication Technology (ICT) infrastructure within these facilities and establishing of broadband-level connectivity underscores the commitment to nurturing a technologically advanced and interconnected healthcare ecosystem. As indicated by a department official "*owned by the ECDoH, the HMS² system eliminates the need for commercial software licensing costs with each healthcare facility implementation, thus minimising overall software expenditure*."

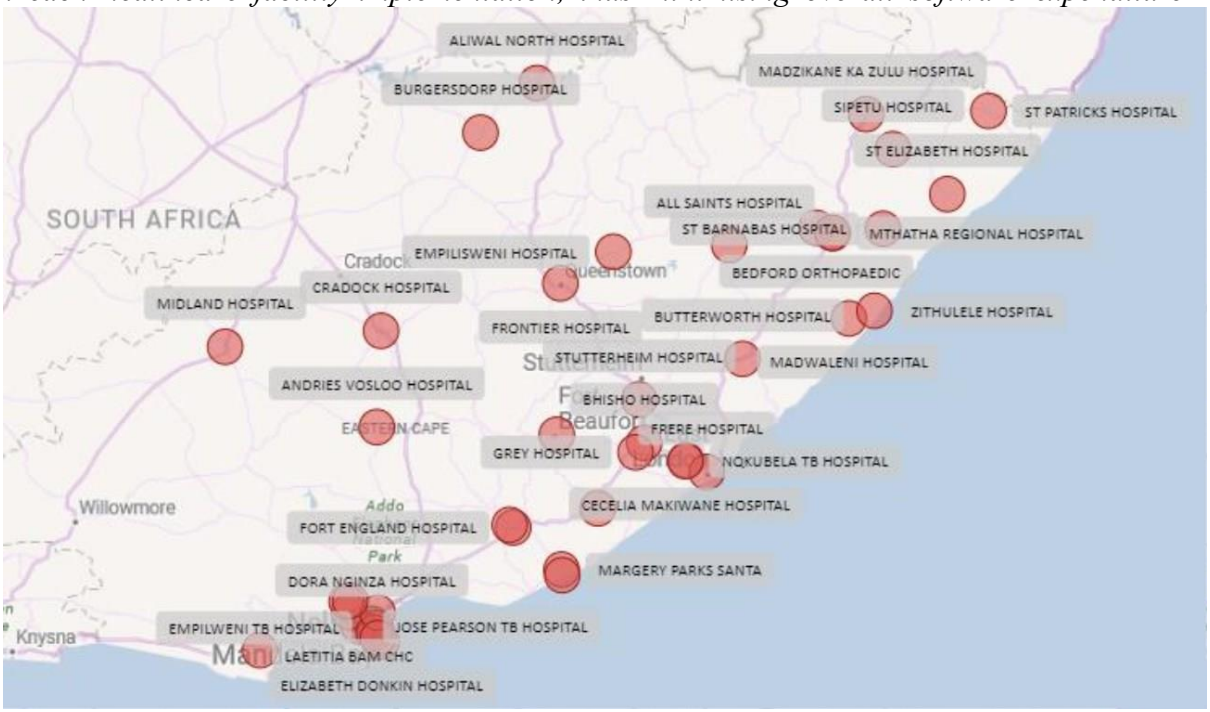

Figure 2-14: Healthcare facilities that received HMS² in the EC Department of Health.

Furthermore, the department's adoption of hardware virtualisation mitigates the necessity for procuring and maintaining large data centres, reducing associated operational costs and the demand for additional engineering resources. This sensible approach facilitates cost savings and ensures efficient resource allocation, with accrued savings being reinvested into further ICT infrastructure enhancements. Beyond provincial boundaries, the impact extends to the Free State Department of Health, which, through a Memorandum of Understanding (MOU), adopted the HMS² system. The successful implementation of Phase 1 across several of the Free State district

hospitals showcases the scalability and adaptability of the system to diverse healthcare settings. Figure 2-15 illustrates which facilities in the Free State adopted the HMS^2 system.

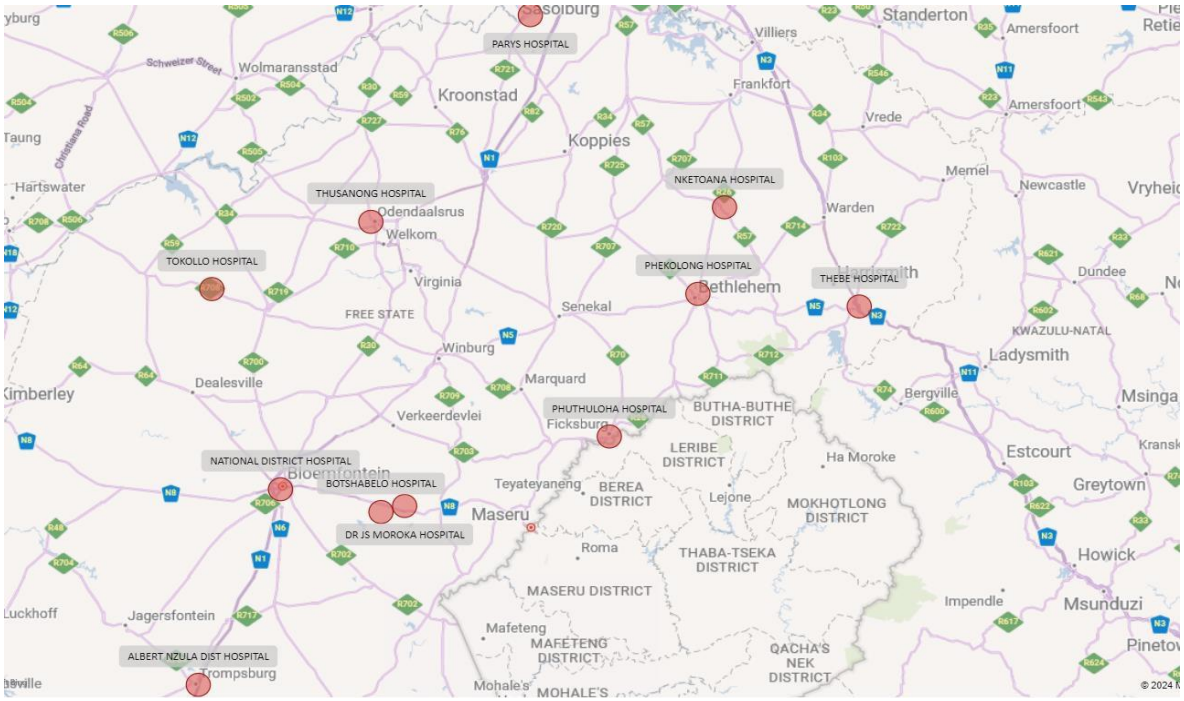

Figure 2-15: Healthcare facilities that received HMS² in the Free State Department of Health

The HMS² system introduced a real-time shared medical record. This transformative feature allows healthcare facilities to seamlessly utilise the system to access and contribute to a patient's medical record, fostering an integrated and collaborative approach to patient care. Healthcare facilities implementing HMS² in this ecosystem can view a patient's medical journey in real time. This shared medical record is a comprehensive repository of the patient's health history, diagnoses, treatments, and other critical information. The accessibility of this information empowers healthcare professionals with a holistic view of the patient's healthcare journey, enabling them to make more informed and coordinated decisions.

Moreover, the real-time nature of the shared medical record ensures that updates or additions to the patient's information are instantly reflected across all connected healthcare facilities. This immediate synchronisation facilitates timely decision-making, reduces redundancy in data entry, and minimises the risk of errors associated with outdated or incomplete information. Healthcare professionals across different facilities can collaboratively contribute to the shared medical record. This interconnected approach enhances communication and coordination among healthcare providers, promoting a patient-centred model of care. Whether an emergency service is accessing critical information or a hospital updating the patient's ongoing treatment plan, the shared medical record ensures that the entire healthcare team is well-informed. As a department official indicated, "*the real-time shared medical record in HMS² streamlines healthcare delivery and plays a crucial*

role in emergencies where quick access to accurate patient information can be a matter of life and death." This level of interoperability aligns with the overarching goal of the ECs eHealth steering committee to create a connected and responsive healthcare ecosystem.

2.12 Quantifiable Achievements during this period Reflect the Tangible Benefits of the eHealth Initiatives.

Since the integration with HPRS in December 2022, as of 25 June 2024, around 718 thousand patient requests were sent from HMS² to HPRS without human intervention, using the HNSF, of which 435 thousand patients were identified, and the HPRS patient demographics and Patient Reference Number are used within hospitals (see Figure 2-16):

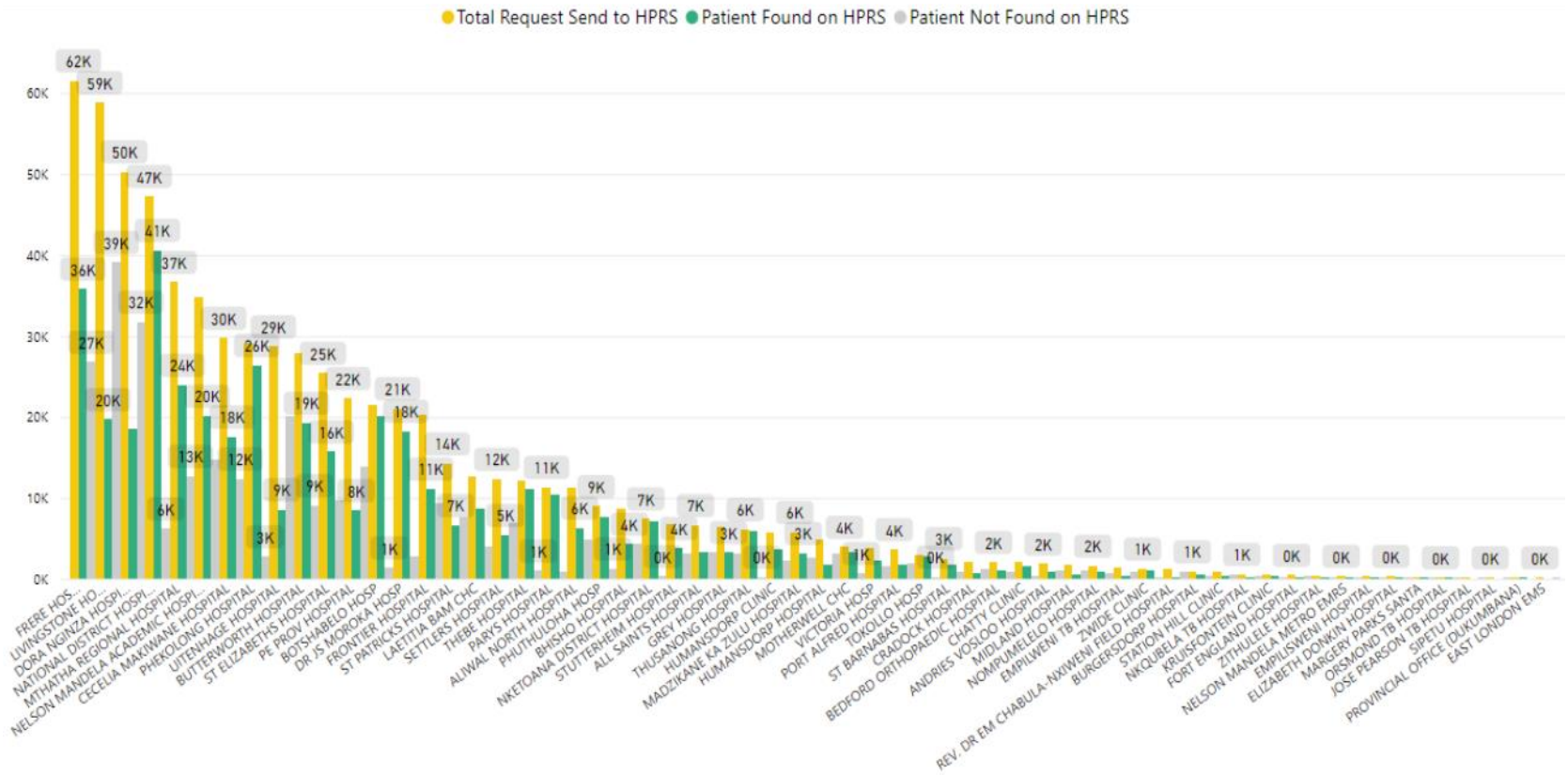

Figure 2-16: HMS² to HPRS example usage patterns

- Approximately 5.5 million patient demographic records were successfully onboarded across the Eastern Cape and Free State Departments of Health, streamlining patient information management.
- Over 2.3 million outpatient department visits were processed, highlighting the efficiency gains in managing and tracking patient interactions.
- The eHealth system's impact on inpatient care is evident in processing more than a million inpatient admissions and separations, showcasing the system's capacity to handle the complexities of hospital admissions, transfers and discharges and improve overall patient care coordination.
- The integration of National Health Laboratory Service (NHLS) lab results, boasting around 27 million lab results, emphasises the system's contribution to data-driven decision-making and the seamless flow of critical diagnostic information.
- An instrumental achievement has been the successful implementation of a centralised Medico-Legal Case Management system, effective since 2020. This system plays a pivotal role in the comprehensive management of all medico-legal claims against the Department, providing a unified and streamlined approach to handling such cases. Notably, this module is actively utilised across the entirety of the Eastern Cape Department of Health, fostering interdepartmental collaboration with key stakeholders including the EC Office to the Premier, Provincial Treasury, and strategic partners.
- Another accomplishment is the establishment of a central Promotion of Access to Information Act (PAIA) module. This module, implemented to record and manage all Requests for Information (RFI) directed to the Department, represents a significant step forward in ensuring transparency and compliance with information access regulations. The centralised PAIA module enhances efficiency in managing and responding to information requests while facilitating seamless coordination between different units and departments within the organisation.
- A notable achievement in the Department's ongoing efforts to enhance information accessibility to its facilities is the successful implementation of third-party systems analysis. This innovative approach enables our hospitals to generate detailed reports on their Human Resources (HR) analysis. Leveraging source data from PERSAL, this initiative empowers healthcare facilities with valuable insights into their HR metrics. This achievement not only enhances the data-driven decision-making capabilities of our facilities but also exemplifies our commitment to leveraging technology for improved analysis and strategic planning in healthcare management.
- SANBS Integration: Around 330, 000 SANBS product results are stored.
- As a significant milestone in enhancing maternity records is a pilot initiative at Frere Hospital, achieving interoperability with the EC Phillips CTG that successfully resulted in

the electronic linkage of approximately 11, 000 Cardiotocography (CTG) reports to maternal records stored on HMS² in real-time. Building on this success, the Department is strategically planning to expand this integration to additional facilities in the near future. The benefits of this integration are manifold. First and foremost, it enhances the accessibility and completeness of maternal records by seamlessly incorporating CTG reports, providing a more holistic view of the patient's health history. This integration also streamlines data management, reducing manual efforts associated with record linkage. Additionally, it contributes to improved clinical decision-making by ensuring that vital diagnostic information is readily available within the patient's electronic health record.

- A notable achievement in the integration efforts is completing a pilot program at Frere Hospital, where approximately 350 thousand digital radiology requests were seamlessly transmitted from HMS² to the hospital's digital radiology system (RIS). This milestone demonstrates the effectiveness of the system integration capabilities and highlights the potential for significant improvements in the efficiency of radiology services going into the future. The Department is committed to extending this functionality to more hospitals over the Medium-Term Expenditure Framework (MTEF) in the near future, ensuring that the benefits of streamlined digital radiology request processes are realised across a broader spectrum of healthcare facilities. This achievement underscores our dedication to leveraging technology for enhanced healthcare delivery and operational efficiency.

Figure 2-17 provides an example of the Master Patient Index in the HMS^2.

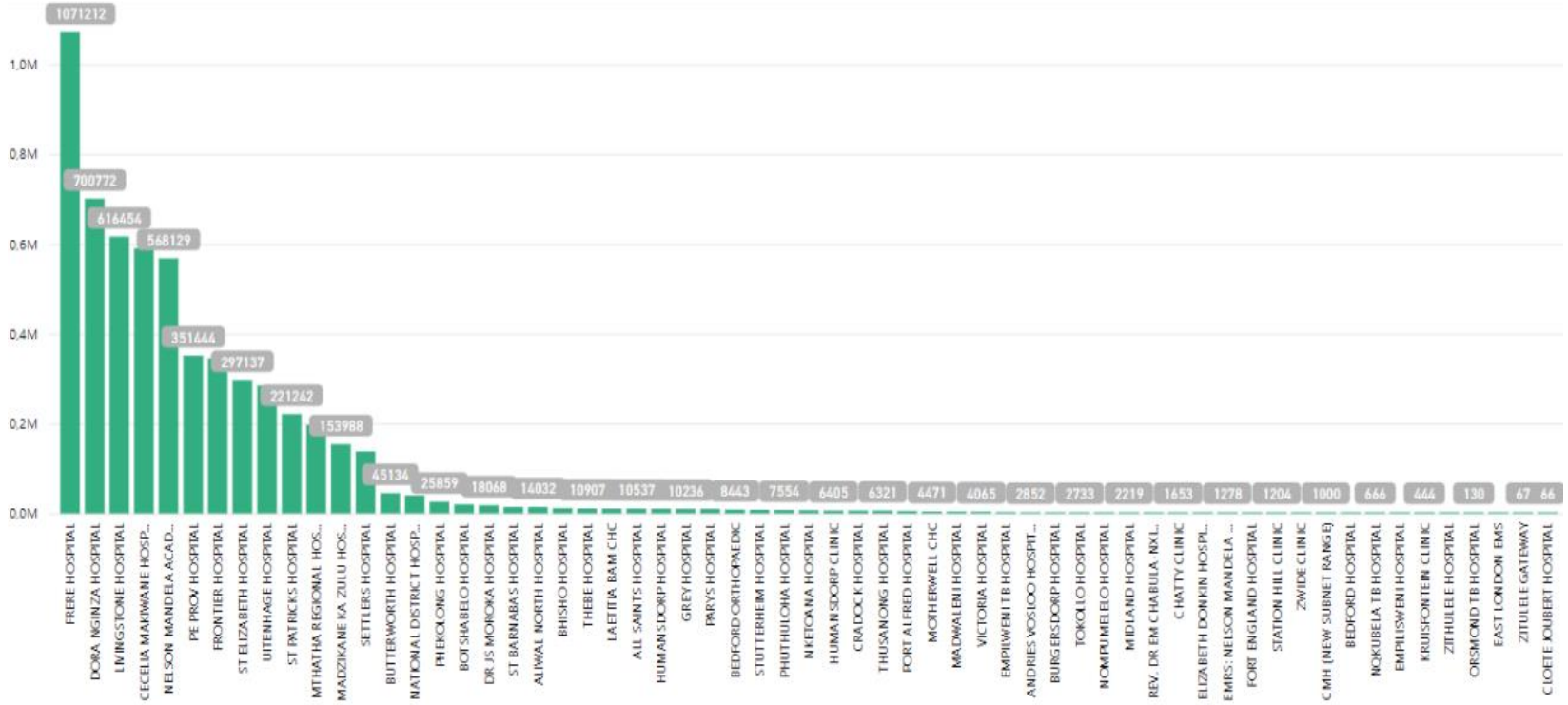

Figure 2-17: Master patient index example (MPI)

In conclusion, the outcomes and impact of the eHealth steering committee's initiatives showcase a paradigm shift in healthcare management. From infrastructure upgrades to the successful deployment of HMS² modules, the eHealth system has become a cornerstone in enhancing patient care, operational efficiency, and data-driven decision-making. As the phased implementation continues, the positive impact on healthcare delivery is poised to grow, reinforcing the commitment to excellence in the digital transformation of healthcare services.

2.13 Lessons Learned

In the dynamic landscape of systems implementation, valuable lessons are inevitably learned during system pilots and the overall implementation process. Adopting a design thinking approach becomes instrumental in this context, emphasising agility and iterative problem-solving. Design thinking is a human-centred methodology that emphasises empathy, encouraging a deep understanding of end-users' needs, challenges, and experiences. This approach involves continuous collaboration, prototyping, and testing to refine solutions based on real-world feedback. Design thinking promotes an iterative and adaptive mindset when applied to lessons learned during system implementation (Beckman, 2020). It encourages project teams to empathise with users, define problem areas, ideate potential solutions, prototype, and test these solutions in an ongoing cycle. This iterative process ensures that lessons learned are acknowledged and actively incorporated into the evolving design, fostering continuous improvement and resilience in the face of complex implementation challenges.

Several challenges have been experienced during the implementation of the HMS² system. These challenges highlight the complex nature of healthcare technology initiatives and the need for comprehensive strategies to address them:

- Load Shedding and Power Challenges: Load shedding severely impacts healthcare facilities, necessitating innovative strategies to stabilise power within these facilities. Such instability affects all systems and devices reliant on power, highlighting the critical need for solutions to mitigate its effects. In the Eastern Cape, rural areas often encounter the most challenges with inconsistent power supply due to load shedding, which directly impacts the implementation of electronic systems. This interruption disrupts data collection, storage, and communication. The system's functionality could be severely compromised without a reliable power source, leading to data loss or inaccuracy.
- Connectivity Issues: The State Information Technology Agency (SITA) and connectivity services provided face hurdles in maintaining consistent connectivity, primarily due to load shedding and infrastructure theft, which further results in slow responses to faults.
- Data Quality and Standardisation: Ensuring data accuracy, completeness, and standardisation across different healthcare facilities has been a persistent challenge. Varied data formats and quality inconsistencies can hinder the system's effectiveness and compromise decision-making.

- User Training and Adoption: The successful implementation of healthcare information systems heavily relies on end users' effective training and adoption. Resistance to change, especially among healthcare professionals unfamiliar with digital systems, can slow the integration process.
- Integration with Existing Systems: Integrating the HMS² with existing healthcare systems and technologies poses challenges, particularly when legacy systems use different standards or technologies. Ensuring seamless interoperability without disrupting daily operations is a complex undertaking.
- Security and Privacy Concerns: Safeguarding patient data and maintaining confidentiality are paramount in healthcare. Addressing security and privacy concerns, including compliance with data protection regulations, adds a layer of complexity to system implementation.
- Budget Constraints and Resource Allocation: Healthcare technology initiatives often face budget constraints and resource allocation challenges. Balancing the need for technological advancements with limited financial resources requires strategic planning and prioritisation.
- Regulatory Compliance: Navigating the intricate landscape of healthcare regulations and ensuring compliance with evolving standards is a continuous challenge. Staying updated with regulatory changes and aligning the system accordingly is crucial for sustained success.
- User Experience and Interface Design: Designing an intuitive user interface and optimising user experience is critical for system acceptance. Complex interfaces or poorly designed user experiences can impede efficient workflows and hinder user satisfaction.
- Scalability for Future Growth: A scalable architecture requires a scalable architecture to anticipate and accommodate future growth in terms of the number of users, data volume, and additional functionalities. Failure to plan for scalability may result in system limitations and bottlenecks.
- Change Management: Managing organisational change, including cultural shifts and altered workflows, is crucial for successful system implementation. Resistance to change and ineffective change management strategies can impede progress.
- Stakeholder Management: Coordinating with end users, managing expectations, and aligning diverse stakeholder interests require effective communication and collaboration.

2.14 Recommendations

These recommendations aim to guide others in navigating similar challenges in healthcare technology initiatives:

- Boldness and unwavering commitment: Undertaking Information and Communication Technology (ICT) infrastructure overhauls and complex system implementations can

undoubtedly present numerous challenges and complexities. However, it is imperative to remain steadfast and resolute in pursuing these initiatives, even in adversity. Boldness and unwavering commitment are essential traits in navigating the intricacies of such endeavours.

- Maintain a clear vision and objectives throughout the process. Establishing well-defined goals and strategies will provide a guiding framework for decision-making and resource allocation. It is also paramount to foster open communication and collaboration among stakeholders, including IT professionals, healthcare personnel, and administrators. This collaborative approach ensures alignment of efforts and facilitates the effective resolution of obstacles encountered along the way.
- Iterate and refine strategies: Perseverance and determination are key despite inevitable setbacks and obstacles. It is essential to anticipate and prepare for potential roadblocks as much as possible while maintaining a proactive and adaptable mindset. Flexibility in approach, coupled with a willingness to iterate and refine strategies as needed, will ultimately contribute to the success of any project.
- Data Quality and Standardisation: Establish robust data governance practices early in the project. Clearly define data standards, provide training on data entry protocols, and implement regular data quality checks. Utilise data validation tools to ensure consistency and accuracy across the system.
- User Training and Adoption: Prioritise comprehensive user training programs catering to healthcare professionals' diverse skill levels. Implement user-friendly interfaces and offer ongoing support mechanisms. Engage end users in the system design and development process to foster a sense of ownership.
- Integration with Existing Systems: Conduct a thorough analysis of existing systems and ensure compatibility through standardised interfaces and protocols. Collaborate closely with IT departments and vendors to develop seamless integration strategies. Employ middleware solutions to bridge the gap between different technologies.
- Security and Privacy Concerns: Implement robust cybersecurity measures, including encryption, access controls, and regular security audits. Develop and enforce strict privacy policies in alignment with healthcare regulations. Provide training on security best practices for all system users.
- Budget Constraints and Resource Allocation: Conduct a comprehensive cost-benefit analysis and prioritise essential functionalities within budget constraints. Seek partnerships and explore funding opportunities from government initiatives or private sector collaborations. Emphasise the long-term return on investment (ROI) of the healthcare technology.
- Regulatory Compliance: Establish a dedicated compliance team or work closely with legal experts to monitor and interpret regulatory changes. Develop a proactive compliance

strategy that includes regular audits and updates to align the system with evolving standards. Engage with regulatory bodies for guidance.

- User Experience and Interface Design: Prioritise user experience in system design, ensuring simplicity, intuitiveness, and efficiency. Conduct usability testing with end users to gather feedback and make iterative improvements. Involve end users in the interface design process to ensure it aligns with their workflows.
- Scalability for Future Growth: Design the system architecture with scalability in mind. Utilise cloud-based solutions and scalable infrastructure to accommodate future growth seamlessly. Regularly assess system performance and scalability requirements to make informed adjustments.
- Change Management: Develop a comprehensive change management plan that includes communication strategies, training programs, and feedback mechanisms. Engage with key stakeholders early and address concerns through transparent communication. Establish a culture of continuous improvement and adaptability. Implementing a new system like HMS² necessitates a comprehensive change management strategy. Resistance to change, lack of user training, or inadequate communication about the new system's benefits could impede its successful adoption. Ensuring stakeholder buy-in, training programs, and clear communication channels are critical to navigating these challenges.
- Stakeholder Management: Establish clear communication channels with stakeholders. Clearly define roles, responsibilities, and expectations.

Incorporating these recommendations into healthcare technology initiatives can enhance the likelihood of successful system implementation, foster positive user experiences, and contribute to the overall improvement of healthcare services. Implementing the HMS² system faces multifaceted challenges that demand strategic consideration and meticulous planning.

To mitigate some of these hurdles:

- Infrastructure Improvement: Invest in reliable power backup solutions such as solar or generator setups to ensure continuous system operation, particularly in areas prone to power disruptions.
- Security Measures: Implement security measures to prevent battery theft and vandalism. Collaborate with law enforcement or deploy alternative power sources that are less susceptible to theft.
- Connectivity Redundancy: Ensure close partnership with SITA and approved partners for diverse connectivity solutions, including satellite or mesh networks, to counteract the impact of unreliable fix and wireless services. Ensure full redundant network connectivity to healthcare facilities and that redundancy is provided across the complete spectrum of the network.

- Comprehensive Change Management: Develop a structured change management plan encompassing user training, stakeholder engagement, and ongoing support to facilitate the smooth adoption of the HMS² system. Overcoming these challenges demands a proactive and multi-pronged approach, integrating technological solutions with effective change management strategies to ensure the successful implementation of the HMS² system despite the adversities posed by power and connectivity issues.
- Manual processes: In case of power and connectivity failures, resorting to a standardised manual process becomes imperative. Facilities can operate manually during downtime, transitioning to electronic recapture once power and connectivity are restored. Regrettably, this situation reflects the reality we encounter in South Africa.

2.15 Conclusion

In conclusion, reviewing the HMS² system within the South African Digital Health Ecosystem underscores its role in advancing healthcare delivery. This review also emphasises the importance of strategic planning and digital innovation in shaping the trajectory of healthcare provision in South Africa. It emphasises the importance of embracing change and accepting that failures will be experienced. It encourages viewing failures as valuable lessons learned, adapting, and staying focused on making a difference in our communities and healthcare facilities instead of giving up.

Moreover, it highlights the fundamental principles of *Batho Pele* (People First) and collaborative efforts in driving technological advancements. Working together, sharing experiences, and holding hands can foster the development of improved technology solutions tailored to the needs of our patients, communities, and healthcare workers. As we navigate the evolving healthcare landscape, continued investment in cost-effective digital eHealth solutions remains imperative for ensuring equitable access to high-quality healthcare services for all citizens. Therefore, integrating digital solutions addresses existing healthcare challenges and lays the foundation for sustainable development and innovation in the sector, ultimately enhancing the nation's well-being and improving efficiencies within our healthcare facilities.

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Chapter 3: Digital Health Ecosystem and Platforms Supporting Health Stakeholders in South Africa

Herselman, M.[1] and Botha, A.[1]

[1]Next Generation Enterprises and Institutions (NGEI) cluster, Council for Scientific and Industrial Research (CSIR), Pretoria, South Africa

Purpose: *This chapter provides an overview of what constitutes Digital Health, Digital Health Ecosystems and Digital Health Platforms and how these can provide value to stakeholders in South Africa.*

Study design/methodology/approach: *The concepts are defined and explained through a scoping review of articles on the topics from 2014-2024. Databases like ACM Digital Library, PubMed, Scopus, IEEE, Science Direct and SAGE were used to identify suitable articles related to these topics based on inclusion criteria. In total, 187 suitable articles were identified and used to provide information on the topics and to understand the challenges, building blocks, design elements, and realities of these concepts in an African context.*

Originality/value: *The South African Digital Health Strategy, as developed in 2019, was then scrutinised to determine if the concepts were addressed and what the strategy indicates should happen to realise a Digital Health Ecosystem for South Africa. It was found that most of the concepts were addressed, and that the strategy prioritises the essential aspects relating to Digital Health, Digital Health Ecosystems and Digital Health platform Ecosystems. These concepts are then summarised and grouped in a figure to show the complexity. Afterwards, a conceptual framework is provided to show the relatedness of the concepts.*

Keywords: *Digital Health, ecosystems and Digital Health platform Ecosystems, Digital Health Strategy, South Africa*

3.1 Introduction

In today's healthcare landscape, digital health technologies are transforming how we approach health and well-being. Strategic initiatives from leading health organisations guide this transformation. Among these, the World Health Organisation (WHO) has played a pivotal role, especially highlighted in its 2021 strategy, which emphasises the significance of digital health in creating interconnected healthcare communities. The 2021 strategy advocates for the use of technological infrastructure across all care settings to ensure a unified health ecosystem (WHO, 2021).

South Africa has made significant progress in the past ten years towards incorporating digital health into its national healthcare system, drawing inspiration from the World Health Organisation's (WHO) agenda. The South African Digital Health Strategy, which was developed by the National Department of Health (NDoH) in 2019, represents a significant step towards achieving this objective. In order to achieve this goal, it is necessary to develop a digital health ecosystem comprising people, processes, and technology that are all in collaboration with one another. Through strengthening health systems, improving service delivery, enhancing patient care, and empowering patients, such an ecosystem aims to contribute to the overarching aim of Universal Health Coverage (UHC) (NDoHS, 2019).

Research supports the notion that digital health technologies—encompassing telemedicine, artificial intelligence, wearable devices, cloud computing, mobile health, big data, and electronic health records—have the potential to accelerate progress towards the Sustainable Development Goals (SDGs). This is particularly true for SDG 3, which focuses on ensuring everyone's health and well-being. Despite the promising outlook, the realisation of these technologies' full potential in Africa is contingent upon addressing existing challenges in infrastructure and training (Ibeneme et al., 2022; Manyazewal et al., 2023; Manyazewal et al., 2021; van Stam, 2022).

This chapter delves into the foundational elements of digital health and its ecosystems, aiming to provide insights into how they can deliver widespread benefits across South Africa's healthcare landscape. The initial groundwork laid by research conducted from 2016 to 2019 on Digital Health Innovation Ecosystems in South Africa and Namibia has been instrumental in shaping our understanding of these concepts (Herselman et al., 2016; G. Iyawa et al., 2016; G. E. Iyawa et al., 2016; Gloria Ejehiohen Iyawa et al., 2017b; Gloria E Iyawa et al., 2017; Labrique et al., 2013; Mehl et al., 2018). Furthermore, recent advancements, research findings, and strategic documents have enriched this knowledge base, offering nuanced recommendations for leveraging digital health ecosystems to enhance global health and well-being (NDoHS, 2019; WHO, 2021).

By providing a clear and accessible overview, this chapter seeks to engage both academic and general readers in understanding the dynamic field of digital health in South Africa. This discussion is part of The Emerging South African Digital Health System: Strategies, Approaches, and Experiences. It is designed to navigate the intricacies of digital health, highlighting its potential to revolutionise healthcare delivery and outcomes in the region.

3.2 Methodology

This paper followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines (Moher et al., 2009; Tricco et al., 2018). Five key phases were followed: (a) identifying the research question, (b) identifying relevant studies, (c) study selection, (d) charting the data, and (e) collating, summarising, and reporting the results that acknowledge the work of Arksey and O'Malley (2005) and Pham et al. (2014). The scoping framework was applied to map the relevant Digital Health (DH) literature using a wide

range of research and non-research types of evidence. Due to the complex and heterogeneous nature of the domain of search, a scoping review was employed to bring conceptual clarity to the specific research topics from diverse materials and perspectives. No meta-analysis was attempted accordingly.

3.2.1 Identifying Relevant Studies

Studies were identified using a systematic search method, including pre-defined selection criteria. The search included major library databases (ACM Digital Library, PubMed, Scopus, IEEE, Science Direct, SAGE) and grey literature covering publications from 2014 to 2024.

3.2.2 Study Eligibility Criteria.

The review material included clinical trials, exploratory, field, experimental, systematic review, qualitative, and quantitative studies. The challenge was to paint a big picture out of the literature on the topic, so the inclusion process was not limited to studies of one type. Consequently, a review included research articles and strategic documents. The inclusion criteria were only studies published in English, studies referring to all countries, and studies in digital health, innovation, digital ecosystems, and digital health platform ecosystems.

3.2.3 Data Synthesis and Analysis

There were 123 publications on digital health, 51 on digital health ecosystems, and 13 on DH platform ecosystems that met the inclusion criteria. In total, 187 publications met the inclusion criteria. The PRISMA below summarises how the papers were scrutinised to get to the final total of 187.

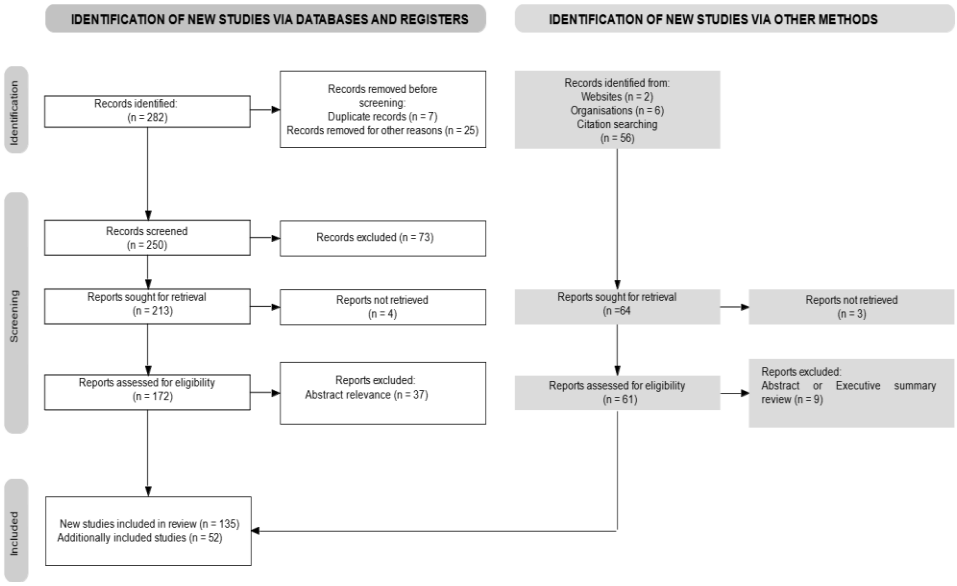

Figure 3-1: Prisma Identification of records included

The findings of the scoping review of the 187 publications will be discussed in the following sections.

3.3 Discussion

3.3.1 Digital Health (DH): Definition and Advantages

The exploration of digital health (DH) across various academic and industry landscapes reveals a vibrant but complex field characterised by its breadth and diversity of definitions and applications. A review of the literature generated 123 publications, indicating the significant interest and research activity in this area. Despite the wealth of information, a consensus on a precise definition of digital health remains elusive, a challenge highlighted by Fatehi et al. (2020). This lack of consensus is further compounded by the varying perspectives of academic circles, scientific institutions, industry stakeholders, and individuals, making a unified understanding of digital health challenging. The Organisation for Economic Cooperation and Development (OECD) (2023) repeats this sentiment, pointing out that inconsistent terminology makes digital health difficult to grasp and, hampers cross-border collaboration, and stifles the scaling of innovations that could enhance health outcomes.

The scope of digital health is vast, with interpretations ranging from the types and uses of digital technologies to strategies aimed at overhauling healthcare delivery and facilitating comprehensive health system transformation (HIMSS, 2021). A more specific definition comes from G. Iyawa et al. (2016), who describes digital health as enhancing healthcare provision. This enhancement is achieved through information and communication technologies that monitor and improve patient well-being and empower patients and their families in managing health. The World Health Organisation (WHO) builds on this by defining digital health as the field concerned with developing and utilising digital technologies to improve health. This definition encompasses eHealth and extends to a wider array of smart, connected devices that enrich users' lives, along with applications in robotics, artificial intelligence (AI), big data analytics, and more (WHO, 2021).

The OECD Indicators (2023) further refine our understanding of digital health by expanding on these definitions. It includes a broader range of smart devices, connected equipment, and digital therapeutics, emphasising the role of digital consumers. It also highlights the importance of data and digital technologies in health system improvement, public health preparedness, research, and innovation, incorporating elements like the Internet of Things, AI, and big data.

For this paper, we will adopt the OECD's comprehensive definition of digital health. This definition underscores the transformative power of digital tools and health data in delivering health services, managing chronic conditions, and enhancing public health. Digital health's role is increasingly vital, as seen through electronic health records (EHRs), population health data for policymaking, and the integration of telemedicine into routine care (Sutherland, 2023). An

integrated approach to digital health supports responsible AI and analytics use, ensuring secure data sharing across care and administrative settings (OECD Indicators, 2023).

The transformative impact of digital health is multifaceted. It is not only a determinant of health through digital technologies, access, and literacy but also reshapes patient and healthcare-provider interactions. Patients are placed at the centre of this transformation, empowered with tools to monitor, manage, and enhance their care, thereby becoming more knowledgeable and self-reliant (Deetjen et al., 2020). Saunders et al. (2022) highlight the value-creating outcomes of digital health, including improved health outcomes, cost reductions, and stimulating economic growth through high-quality employment and investment.

The WHO advocates for the benefits of digital health to be realised in a just, safe, secure, equitable, and sustainable manner. Essential principles such as transparency, accessibility, scalability, and privacy must guide the development of digital health technologies (WHO, 2021). Additionally, digital health data plays a critical role in tailoring treatments and medications, offering insights into the future of healthcare—a future made increasingly relevant by the surge in demand for digital health services during COVID-19 lockdowns (Schröder et al., 2021).

Ultimately, digital health focuses on enhancing patient care and well-being, utilising innovative technologies to support digital transformation, research, innovation, and create value. The key to unlocking its full potential lies in adopting ecosystem approaches that integrate various services and solutions, facilitating seamless patient journeys (Deetjen et al., 2020).

3.3.2 The Evolution and Impact of Digital Health Ecosystems

Over the past decade, the healthcare field has undergone a profound transformation, driven mainly by remarkable advancements in information technology. These innovations have reshaped the traditional healthcare delivery model, embedding emerging devices and advanced systems into a network that collectively functions as an ecosystem. This ecosystem aligns a multilateral set of partners, including healthcare providers, technology developers, patients, and insurers, working together to realise a central value proposition. Adner (2017) initially introduced this concept, defining an ecosystem as the structured alignment of partners necessary for a focal value proposition to materialise.

Building upon Adner's foundational work, Deetjen et al. (2020) emphasised the critical role of ecosystem approaches in integrating digital health (DH) solutions into the existing healthcare infrastructure. They argue that such approaches are pivotal for two primary reasons. Firstly, they enable the creation of a central platform endowed with standard data management functions, such as patient authentication and data privacy. This platform, prepopulated with essential data from the health system (e.g., claims data) and featuring single sign-on across solutions, facilitates a more contextually relevant experience for patients. Secondly, they highlight the importance of incorporating patient-generated data back into the health system. This integration not only

improves care delivery and system navigation but also enables the evaluation of the effectiveness of specific interventions (Schröder et al., 2021).

Furthermore, these ecosystem approaches create substantial value across the entire traditional healthcare sector. They enhance patient services and convenience by providing either stand-alone or seamlessly integrated digital offerings throughout the patient journey (Saunders et al., 2022; Viswanadham, 2021), guide patients towards optimal treatment options, thereby offering value for insurers, and increase transparency and efficiency for all participants to maximise the system's overall value (Deetjen et al., 2020).

Echoing and extending the insights of Deetjen et al. (2020), Oshni Alvandi et al. (2021) support the notion that a Digital Health ecosystem is a network comprising health industry and technology components that mutually influence their operation, evolution, and development while delivering healthcare services. In this context, components encompass a human population with dynamic characteristics, healthcare actions, and information flow and transactions related to healthcare episodes (Gloria Ejehiohen Iyawa et al., 2017a, 2017b; Gloria E Iyawa et al., 2017). This concept aligns with the definition of Digital Health Innovation Ecosystems delineated by Iyawa et al. (2019), which describes a network of digital health communities. These communities comprise interconnected, interrelated, and interdependent digital health entities, including stakeholders, institutions, and devices in a digital health environment. These entities adopt best practices demonstrated to be successful and implement these through information and communication technologies to monitor and enhance patient well-being, empowering patients in managing their health and that of their families.

In distinguishing Digital Health ecosystems from Digital Health platforms, Oshni Alvandi et al. (2021) highlight these ecosystems' complexity and collaborative nature. Unlike platforms that primarily serve as a technical base, ecosystems encapsulate a broader range of interactions and relationships, fostering a collaborative environment where various components work together to improve healthcare outcomes. This holistic approach underscores the potential of digital health ecosystems to revolutionise healthcare delivery, making it more efficient, patient-centred, and integrated.

3.3.3 Digital Health Platform Ecosystem

Jovanovic et al. (2022) and Ruokolainen et al. (2023) delve into the nuanced dynamics of platform ecosystems, shedding light on their role as evolving meta-organisational forms. These ecosystems are characterised by an enabling platform architecture and governed by mechanisms essential for the cooperation, coordination, and integration of diverse organisations, actors, activities, and interfaces. This integration process catalyses an increase in platform value for customers through the provision of customised platform services. Digital platform ecosystem participants employ digital technologies to manipulate and control digitised resources extending beyond a firm's immediate scope, crafting value by facilitating connections across multiple sides, influenced by

cross-side network effects (Viswanadham, 2021). These ecosystems can manifest as products, services, systems, or technologies, each embodying modularity and the flexibility essential for joint value-creation efforts (Adner, 2017).

The design principles underpinning these ecosystems often include the use of service-oriented architecture (SOA) and RESTful API interfaces (an interface that two computer systems use to exchange information securely over the internet), delivering data in formats like JavaScript Object Notation (JSON) or YAML Ain't Markup Language (YAML) as the most popular programming languages. Tools like Swagger are utilised to craft YAML-based application protocol interfaces (APIs), streamlining software development processes. These technical attributes underscore the ecosystems' modularity and adaptability, enabling seamless connections between platform module developers, end customers, and other developers (Ruokolainen et al., 2023).

However, Ruokolainen et al. (2023) argue that understanding platform ecosystems as merely technological constructs overlooks their complex nature; they are socio-technical phenomena, integrating a technical core with business networks that navigate both social and technical challenges. This perspective highlights the ecosystems' capacity to serve as conduits for big data utilisation in personalised patient healthcare, as Sousa et al. (2019) noted. Integrating big data into these ecosystems can lead to groundbreaking advancements in disease treatment through data collected remotely by digital healthcare platforms, facilitating the creation and centralisation of specific knowledge domains. Such ecosystems can transform healthcare delivery, making it accessible, timely, and cost-effective even in remote locations, thereby democratising healthcare services (Iyawa et al., 2019; Ruokolainen et al., 2023).

While interrelated, digital health ecosystems and platform ecosystems serve distinct purposes within the healthcare domain. The latter's defining features—enabling architecture, governance mechanisms, and the strategic use of digital technologies for resource control and value creation—underscore their pivotal role in integrating diverse organisations, actors, and activities. This integration fosters value creation through customised services, leveraging the ecosystems' inherent modularity and flexibility. The convergence of these ecosystems presents a forward-looking model for healthcare delivery, emphasising the importance of both technological innovation and socio-technical integration in addressing contemporary healthcare challenges.

3.3.4 Design Elements of a Digital Health Ecosystem

The establishment and growth of digital health (DH) ecosystems are contingent upon integrating certain critical design elements that collectively form the foundation of these complex networks. Central to this framework is the role of orchestrators, entities that align incentives among diverse data sources, creating a centralised and secure platform for data exchange. This structure facilitates the efficient and safe transfer of information and ensures that all parties involved generate clear value from their participation (Deetjen et al., 2020; Oshni Alvandi et al., 2021).

A foundational requirement for these ecosystems is the development of a basic infrastructure that supports seamless data exchange among different stakeholders. This infrastructure is enabled by a trusted party that oversees the ecosystem, ensuring data integrity and security. At the heart of such an ecosystem lies a patient-centric gateway equipped with essential functionalities for partner management, including authentication and authorisation. This approach prioritises patient needs and privacy, establishing a trustworthy and user-friendly interface for accessing healthcare services.

Moreover, the ecosystem architecture incorporates digital health solutions with standardised, externally documented application programming interfaces (APIs). These APIs are designed to facilitate ecosystem partners' effortless integration, support standard workflows, and enable a cohesive operational environment (Ruokolainen et al., 2023). The infrastructure's scalability is crucial, underpinned by medical cloud functionality and scalable IT foundations, to accommodate the dynamic expansion of the ecosystem. This scalability is instrumental in leveraging the dynamics of two-sided markets, where an increase in the number of partner offerings attracts new patients, and a growing patient base, in turn, draws more partners to offer their services. As the ecosystem expands, this reciprocal growth mechanism ensures that all parties benefit, creating a win-win situation for providers and recipients of healthcare services alike (Deetjen et al., 2020).

Both digital health ecosystems and digital health platform ecosystems emphasise the importance of a value proposition that fosters stakeholder involvement, enabling value co-creation and sustained growth. This emphasis underscores the necessity of designing ecosystems that are not only technologically robust but also centred on the principles of collaboration, patient-centricity, and inclusivity. By prioritising these critical design elements, digital health ecosystems can evolve into vibrant, integrated networks that enhance healthcare delivery, improve patient outcomes, and foster innovation in the healthcare sector.

3.3.5 Building Blocks for Digital Health Ecosystems

A digital health ecosystem's construction and effective functioning are predicated upon integrating several critical design elements and foundational building blocks that collectively support its existence and growth. These elements span from governance and data management to interoperability and the employment of advanced analytics.

At the outset, the role of orchestrators is paramount. As highlighted by Deetjen et al. (2020) and Oshni Alvandi et al. (2021), orchestrators align incentives among various data sources, establishing a centralised and secure platform for data exchange. This alignment is critical in ensuring that each party derives clear value from their participation, fostering a collaborative and mutually beneficial environment. The orchestrator's role oversees the basic infrastructure required for data exchange, underpinned by trusted mechanisms that facilitate authentication and authorisation.

The digital health ecosystem's architecture emphasises patient-centric gateways, which are foundational to partner management. These gateways, equipped with standardised Application Programming Interfaces (APIs), enable effortless integration of ecosystem partners and support standard workflows (Ruokolainen et al., 2023). Such an infrastructure is designed for scalability, leveraging medical cloud functionality and scalable IT foundations to accommodate the dynamics of two-sided markets. The resultant effect is a virtuous cycle where an increasing number of offers from partners attracts new patients, and a growing patient base, in turn, draws more partners to offer their services, thereby propelling the ecosystem's growth (Deetjen et al., 2020).

Beyond the technological and operational components, governance and workforce development emerge as critical building blocks. As outlined by HIMSS (2021) and Fatehi et al. (2020), establishing a strong governance and policy framework is essential for ensuring data privacy, security, and accessibility to patients, their caregivers, and provider teams. This framework must also encompass change management strategies to facilitate the adoption of new technologies by citizens and health providers alike.

Interoperability is identified as another cornerstone, enabling the seamless flow of data across the care continuum. This ensures that every provider team working with a patient can access the most recent health data, informing decisions and enhancing care delivery (HIMSS, 2021). However, the mere availability of data is insufficient. Advanced analytics are crucial in mobilising data to assess the effectiveness of care programs and guide decisions regarding patient and family care (Ruokolainen et al., 2023).

In synthesising these insights, it becomes evident that the digital health ecosystem is a multifaceted construct that necessitates a holistic approach to design and management. It combines the technological ability of scalable IT infrastructure and standardised APIs with the strategic oversight of governance and interoperability. This blend ensures the ecosystem's operational efficiency and aligns it with broader goals of enhancing patient care and focusing on population health and wellness over traditional disease management paradigms (HIMSS, 2021; Viswanadham, 2021). The focus on value co-creation, scalability, and governance underscores the ecosystem's potential to revolutionise healthcare delivery by making it more accessible, personalised, and effective.

3.4 The African Context: Challenges and Opportunities

Africa's digital health (DH) ecosystem is at a critical juncture, facing unique challenges stemming from an underdeveloped technological infrastructure and a pressing need for strategic partnerships and investments. Manyazewal et al. (2023) underscore the significance of domestic innovation and international collaboration as pivotal avenues to enhance health and well-being through digital health technologies. These collaborative efforts, as suggested by the World Health Organisation (WHO) in its global strategy on digital health, are essential for fostering cross-national cooperation and knowledge transfer. Such initiatives aim to bridge infrastructure and investment gaps, thereby

facilitating the effective use of digital health technologies to strengthen health systems and address broader health priorities (Holly et al., 2022; Ibeneme et al., 2022; WHO, 2021a).

The literature indicates a lack of characterisation of the cross-national dynamics of Africa's macro-level digital health ecosystem and strategic mapping of high-priority countries for the meaningful and sustainable impact of digital health technologies on citizens' health and well-being. This gap highlights the need for a nuanced understanding of the complex interplay between technological features, such as electricity, population literacy, technology intensity, economy, and information technology infrastructure, including internet and mobile phone access, and their implications for the deployment and use of digital health technologies (Manyazewal et al., 2023).

Smaller economies compound Africa's digital health ecosystem's challenges compared to other continents, which may hinder significant contributions to the digital health landscape (Ibeneme et al., 2022). Yet, untapped opportunities exist for strategic actions that leverage global health initiatives. These initiatives could contribute significantly to overcoming knowledge and investment gaps through technology transfer for local production of digital health technologies and price negotiations for large-scale deployment of impactful technologies. Long-term financial and technical support from global health partners, such as the United States President's Emergency Plan for AIDS Relief (PEPFAR), provides a foundation for transforming digital health interventions in the region, extending to Non-Communicable Disease (NCD) programs, and addressing digital health inequities (Manyazewal et al., 2023).

Countries may initially focus on high-burden diseases using tailored digital health technologies within existing resources. Over time, these technologies could be leveraged and adapted to respond to other health priorities, thereby broadening access to digital health and using HIV-specific resources, technologies, programs, services, and systems to address other health challenges such as Ebola, COVID-19, measles, and NCDs (Holly et al., 2022).

However, the responsibility for infrastructure development and digital health interventions predominantly lies with local governments. Yet, global health initiatives can substantially enhance digital health interventions by bridging knowledge and investment gaps through technology transfer and price negotiation for large-scale deployment of digital health technologies (Holly et al., 2022). Moreover, adopting digital tools in healthcare ecosystems of developing countries faces maturity challenges, with frameworks like RE-AIM (Reach, Effectiveness, Adoption, Implementation, and Maintenance) suggested as useful in structuring implementation research (Jandoo, 2020; WHO, 2021a).

Addressing patients' and healthcare professionals' knowledge, attitudes, and behaviours towards digital health is crucial. These factors significantly influence the adoption and effective use of digital technologies in healthcare. Understanding and mitigating satisfaction levels, apprehensions, hesitations, and fears are vital for fostering acceptance and ensuring the safety of healthcare measures and practices (Jandoo, 2020; Jose et al., 2014).

Digital health represents a technological revolution and evolution and a cultural reform in healthcare. The development of digital solutions must be approached with caution to avoid bias and inequities, striving for disparities in digital health to be addressed during development to ensure uniform and universal benefits to end-users. Sustained efforts are needed to develop digital solutions that are applicable and acceptable in routine patient care in real life, ensuring that digital health advancements contribute positively to the continent's health ecosystem (Jandoo, 2020; Jose et al., 2014).

3.5 South Africa's Digital Health Strategy

The South African Digital Health Strategy (NDoH, 2019) presents a forward-looking blueprint that aligns closely with the broader objectives of establishing a comprehensive digital health ecosystem. This strategy emphasises critical components such as electronic health records, digitising health system processes, interoperability, mHealth for community interventions, and cultivating digital health knowledge workers. Its focus on governance, stakeholder engagement, and capacity development highlights a person-centred approach, underpinning the drive towards innovation and sustainable impact within the digital health domain.

This comprehensive strategy addresses the challenges, design elements, and future directions discussed previously for digital health ecosystems and their associated platforms. It aims to align digital health interventions with the country's health sector priorities, tackling the quadruple burden of disease, enhancing care quality, and supporting the transformation required for National Health Insurance (NHI). Importantly, it targets the fulfilment of Sustainable Development Goal (SDG) 3 by ensuring adequate coverage that extends beyond service delivery to encompass effective treatment and patient outcome monitoring, necessitating robust electronic health records.

Key priorities set by the South African strategy for 2019-2024 include establishing a complete health electronic record system, digitising health systems' business processes, creating an integrated platform and architecture for health sector information systems, scaling up high-impact mHealth for community-based interventions, and developing digital health knowledge workers (NDoHS, 2019). These initiatives are vital for creating a digital health ecosystem that emphasises integrated platforms and architectures for health information systems to ensure interoperability and the seamless integration of new digital health technologies.

The strategy articulates five strategic principles: a person-centred focus, expanded access, innovation for sustainable impact, a digital health workforce for economic development, and a whole-of-government approach. These principles resonate with the essential elements for fostering effective digital health ecosystems, including leadership capacity, multi-stakeholder engagement, sustainable interventions, and robust governance structures. Additionally, it calls for developing a national legislative, policy, and regulatory framework for digital health, highlighting the importance of governance and policy frameworks as foundational building blocks for developing a digital health ecosystem, as indicated in the (WHO, 2021) strategy for digital health.

From analysing the South African Digital Health strategy (NDoH, 2019), it meticulously addresses the key building blocks necessary for developing digital health ecosystems and platform ecosystems. It prioritises infrastructure, governance, stakeholder engagement and offers value propositions to all stakeholders, fostering digitally robust, secure, interoperable, and sustainable health systems. The emphasis on capacity development and a person-centred approach enables innovation. It has a lasting impact, showcasing South Africa's strategic approach as a model for integrating digital health solutions effectively globally.

3.6 Conclusion

From the above discussions, it is evident that South Africa should develop a Digital Health Innovation Ecosystem based on new technologies and developments. Figure 3-2 summarises the most important concepts that should be considered:

The digital transformation of healthcare represents a disruptive yet profoundly beneficial shift towards more effective, efficient, and patient-centred care. Integrating digital therapeutics, clinical trials, self-care management, blockchain, smart wearables, artificial intelligence, big data analytics, and platforms into healthcare systems demonstrates the potential to improve medical diagnosis, treatment decisions, and patient outcomes. These technologies enhance healthcare professionals' knowledge, skills, and competencies and ensure the provision of evidence-based care.

At the heart of this transformation is the imperative to safeguard health information deemed personally identifiable or sensitive personal data through robust cybersecurity measures. The emphasis on trust-building, accountability, governance, ethics, equity, capacity-building, and

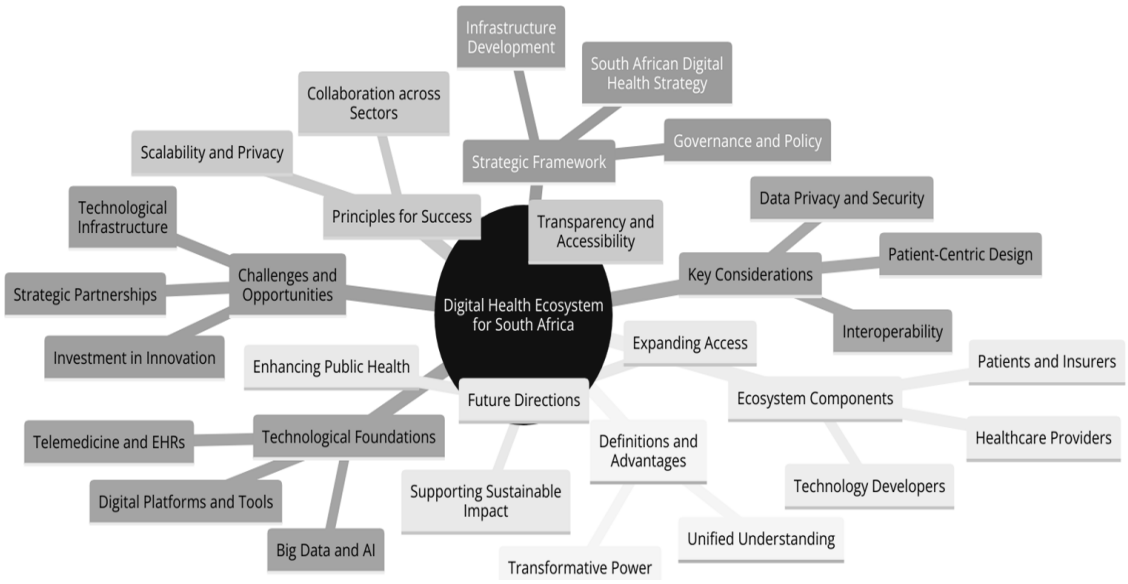

Figure 3-2: Concepts emanating from a rapid scoping review on developing a Digital Health Innovation Ecosystem for South Africa

literacy underlines the critical need for a solid legal and regulatory foundation. This foundation is vital for protecting privacy, confidentiality, integrity, and data availability, facilitating high-quality data collection and sharing for healthcare planning and service transformation while ensuring transparency and effective communication on data security procedures.

An interoperable digital health ecosystem is essential for the smooth and secure sharing of health data among users, healthcare professionals, health system managers, and health data providers. Such an ecosystem, underpinned by universal health care and sustainable health systems, requires a comprehensive strategy integrating organisational, financial, human, and technological resources. Leadership and robust governance mechanisms are crucial to guide digital health initiatives, as demonstrated by the South African Digital Health Strategy and the WHO strategy.

The South African Health Normative Standards Framework (NHSF) of 2022 and the National Health Insurance (NHI) development illustrate the country's commitment to establishing a digital health ecosystem. This ecosystem is expected to address digital determinants of health, such as access to equipment, broadband, and the internet, and competence in information and communication technology—increasingly significant factors, especially in Africa.

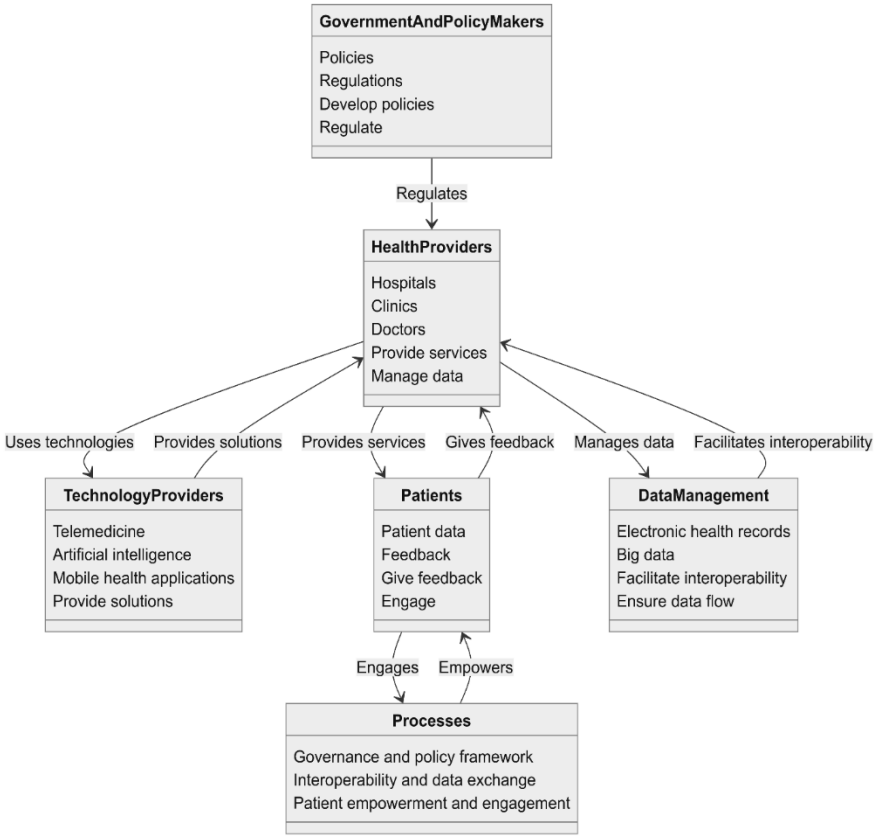

Figure 3 3: Towards conceptualising an improved Digital Health Innovation Ecosystem for South Africa

For digital health to be appropriately utilised, health promotion, disease prevention, patient safety, ethics, interoperability, intellectual property, data security, privacy, cost-effectiveness, patient engagement, and affordability must be considered. Central to these considerations is prioritising people-focused, evidence-based, trustworthy, successful, efficient, sustainable, equitable, and contextualised digital health interventions.

Investing in overcoming barriers to digital health, such as legacy infrastructure, technology ownership, privacy, security, and the adaptation of global standards and technology flows, is crucial. Developing nations, in particular, need a suitable enabling environment, sufficient resources, and infrastructure to support digital transformation alongside education, human capacity, financial investment, and internet connectivity.

Figure 3-3 is a first draft of conceptualising the Digital Health Innovation Ecosystem for South Africa based on the above explanations:

Figure 3-3 depicts the role that government, health and technology providers and patients will play in this ecosystem to ensure that technologies are used, services are provided, and feedback is applied to allow for improvements. At the same time, they engage and are empowered through processes to manage data and facilitate interoperability.

In conclusion, the narratives surrounding digital health and its ecosystems underscore the comprehensive approach taken by the South African Digital Health Strategy and the WHO DH strategy. These strategies encapsulate the latest directions for utilising digital health technologies and the elements essential for developing a digital health ecosystem. Such strategic frameworks are vital for developing countries to ensure the sustainability of their digital health ecosystems. As the field evolves, updating these strategies becomes imperative to incorporate new concepts and technologies that may influence the quality of patient care and wellbeing, demonstrating a global commitment to harnessing digital health to improve healthcare delivery and outcomes worldwide.

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Chapter 4: The FHIR Based Master Household Index

Sibiya, G.[1], Ofori-Appiah, M.[1] and Tolmay, J.P.[1]

[1]Next Generation Enterprises and Institutions (NGEI) cluster, CSIR.

Purpose: *The Integrating the Healthcare Enterprise advocates for integrating distributed and heterogeneous health information systems. This is achieved by developing standards specifying protocols for the integrated systems to communicate as profiles. Integrating the Healthcare Enterprise (IHE) through its Information Technology Infrastructure Technical Framework Volume 2b Transaction B provides a Patient Identification Segment, which allows a patient's demographic details to be exchanged among the information systems within a Health Information Exchange ecosystem. In South Africa, however, healthcare services are extended to communities through Community Healthcare Workers (CHWs) who visit households. Therefore, there is a need to manage households similarly to patients in a Health Information Exchange (HIE) system. The IHE profiles currently do not have explicit profiles in their profiles catalogue that can be utilised to manage households in HIE systems. As opposed to patients being treated as subjects of care, community healthcare workers treat households as subjects of care.*

The COVID-19 pandemic and other epidemics highlighted the importance of associating information inside health systems with corresponding household information. This would assist health workers to efficiently conduct contact tracing to minimise the spread of contractable diseases.

In this chapter, we present a format that can be used to represent household information in a standard that follows the Health Level Seven (HL7) standard. We also present an implementation of an Enterprise Master Household Index equivalent to an Enterprise Master Patient Index that utilises our proposed profile.

In this chapter, a further evaluation of the management of household of care following a FHIR standard will be provided.

Study design/methodology/approach: *The approach in this study was completely experimental. It involved experimenting with existing implementations of a Master Patient Index (MPI). The aim was to investigate if, based on the implementation of an MPI, the concept can be applied to develop a Master Household Index (MHI). This was achieved by proposing a way to manage it in a standard format following a HL7v2 standard format (Sibiya et al., 2017).*

Findings: *This investigation revealed that the household of care could be represented and managed following the HL7v2 standard format. This was experimented with by implementing existing tools developed for a Master Patient Index (MPI). It was found that by implementing the proposed standard format, the household of care could be indexed as it could equivalently be done for patients of care.*

This can add value to a contact tracing process, as it proved necessary at the height of the COVID-19 pandemic.

Keywords: *Household of care, Master Household Index (MHI), HL7v2, FHIR*

4.1 Introduction and Background

In the ever-evolving landscape of healthcare data management, the Fast Healthcare Interoperability Resource (FHIR) standards (HL7, 2023) have emerged as a potent protocol for unifying diverse healthcare systems. This chapter also further explores the application of FHIR standards in managing households of care, addressing the challenges posed by existing protocols and proposing innovative solutions for more comprehensive data representation.

Adopting FHIR standards in healthcare systems signifies a change in basic assumptions towards enhanced data exchange. FHIR's primary objective is to establish a foundational set of resources that can independently or collectively fulfil most common use cases, fostering seamless and on-demand information exchange. As health data interoperability becomes increasingly crucial, the focus shifts to data standards facilitating efficient communication among developers, vendors, and healthcare providers.

This chapter presents an approach that leverages interoperability standards in implementing a seamless exchange of household information. Section 4.3 presents the approach followed in this study, including technical details. Section 4.4 presents the literature, including strategies that informed the approach. Section 4.5 highlights the findings and analysis of the benefits and challenges encountered. Section 4.6 details how end users benefit from and derive value from the presented approach. In section 4.7, the chapter is concluded.

4.2 Theoretical Background

In the field of digital health, standards initiatives are patient and provider-centric in that the focus is on patient information management, patient journey and healthcare service provider information management. The current chapter extends on the proposal to treat a household as a subject as presented in Sibiya, Ofori-Appiah, van Der Walt, Tolmay and Alberts (2017).

Current closely related initiatives propose frameworks that extend health care services to a subject based at home, i.e., home-based primary care (Norman et al., 2018; Ritchie et al., 2021; Wyte-Lake et al., 2022). The HL7 FHIR Clinical Practice Guidelines recognise personas as participants in health care guidelines. They include patients, care partners and home-based personal care workers relevant to the current work (HL7 International, 2024). This provides an opportunity to leverage the FHIR standard and support a household as a participant of which the patient and care partners are members.

One of the South African Digital Health Strategy's priorities is to scale up high-impact mHealth for community-based interventions. Within the context of the NHI, health promotion coverage will be expanded to vulnerable groups such as children, the elderly, women, and others who are prioritised (NDoH, 2019a, p. 18). In relation to the proposed recognition of a household of care, this will allow community healthcare workers to focus on overall household healthcare needs as opposed to individuals within the household. It can enable health workers to monitor it, hence, faster detection of any outbreaks.

The subsequent sections present the strategy and approach demonstrating the applicability of the proposed recognition of a household as a subject of care.

4.3 Strategic Approaches or Experiences Description

The approach in this study was completely experimental. It involved experimenting with existing implementations of a Master Patient Index (MPI). The aim was to investigate if, based on the implementation of an MPI, the concept can be applied to develop a Master Household Index (MHI). This was achieved by proposing a way to manage it in a standard format following a HL7v2 standard format (Sibiya et al., 2017).

The experiment was conducted by developing two applications to pull required attributes from a Community Health Workers (CHW) database. The first application is a customised Mirth Connect application used to pull data from the CHW database (NextGen Healthcare, 2024), transform the data into the respective customised HL7v2 format and push it to the second application. The second application, the CSIR Health Information Exchange, received HL7v2 messages from the Mirth Connect application and persisted the message in the appropriate format to the MHI database.

From an ethical perspective, no ethics review was necessary as the study did not involve human subjects. The information processed through the proposed concept is of the household as a subject of care. At maximum, it can only link human subjects who are members of the household or community healthcare workers with a non-personal identifiable identifier.

A message is the core unit of data exchanged between the Health Information Exchange (HIE) (Adler-Milstein & Dixon, 2016) and third-party systems. Therefore, all communication to and

from the HIE should conform to the HL7 messaging standards. A standard message contains a group of segments in a defined sequence.

Five data schemas have been developed using the presented approach to support household messages in the HIE. The data schemas include household registration in section 4.3.1, household assessment in section 4.3.2, household triage in section 4.3.3, citizen registration in section 4.3.4 and citizen triage in section 4.3.5. The presentation on the message schemas concludes with the architecture that enables the transmission of the messages in section 4.3.6.

The following sections present details on adapting the HL7v2 message formats to support the household as a subject of care.

4.3.1 Household Registration Message

From the HL7 standard, the Admit, Discharge and Transfer (ADT) message (HL7, 2024) contains demographic data of a patient and event triggers on what to do with the message (admit, discharge, transfer, register, merge, etc.). It is generally of the form ADT^A28^ADT-A05 where ADT represents the type of message, A28 is the trigger event and ADT-A05 is the trigger event to pre-admit a patient.

Adapting the message to a household in the context of the HIE means that the consuming message is equivalent to an entity of the type of person. In this respect, the ADT message is converted to RDT^A28^RDT-A05 where RDT means Register, Discharge and Transfer.

The household data template is divided into five major segments:

- MSH Segment – This is the message header segment.
- EVN Segment – This is the event message segment.
- HID Segment – This contains the main data about the household. HID stands for Household Identification.
- XID Segment – This segment contains extra identifiers for the household data collection process. It contains the following data elements:
- Team user details (unique identifier and name).
- Team details (unique identifier and team name).
- Service provider details (unique identifier and name).
- PV1 Segment – This segment contains the visit number.

The next section of ADT in the HL7 standard represents household assessment information.

4.3.2 Household Assessment Message

HL7 does not have a pre-defined template for household assessment data. However, to conform to the HNSF (NDoH, 2021), a match is made with the patient observation to generate the household assessment message. It is based on the ORU^R01^ORU-R30 observation messaging format. The O is replaced by A (Assessment) in the message schema.

The template contains the following segments:

- Message Segment – This is the message header segment.
- AID Segment - This segment contains the assessment identifier. It derives its data elements from the HL7 PID data elements.
- HID Segment – This segment contains the household identifier linked to the assessment. It derives its data elements from the HL7 PID data elements.
- XID Segment – This segment contains extra identifiers for the household assessment data collection process. It contains the following data elements:
- Team user details (unique identifier and name).
- Team details (unique identifier and team name).
- Service provider details (unique identifier and name).
- ASR Segment – This segment contains the assessment control results.
- ASX Segment – This segment contains the assessment results. It derives its data elements from the HL7 Observation (OBX) data elements (Caristix, 2024a).

The first four segments have the same format as the Household Registration Message; the additional segments, ASR and ASX, represent assessment control results and results, respectively. In the next section, the triage specific to a household is presented.

4.3.3 Household Triage

The household triage template is designed based on the HL7 patient observation template. The template contains the following segments:

- MSH Segment – This is the message header segment.
- AID Segment - This segment contains the triage identifier. It derives its data elements from the HL7 PID data elements (Caristix, 2024b).
- HID Segment – This segment contains the household identifier linked to the triage. It derives its data elements from the HL7 PID data elements.
- XID Segment – This segment contains extra identifiers for the household triage data collection process. It contains the following data elements:

- Team user details (unique identifier and name).
- Team details (unique identifier and team name).
- Service provider details (unique identifier and name).
- ASR Segment – This segment contains the triage control results.
- ASX Segment – This segment contains the triage results. It derives its data elements from the HL7 Observation (OBX) data elements. The segment is repeated for each triage response.

Each segment is in the same format as the Household Assessment message segments. In the next section, the registration aspect of the citizen information is presented.

4.3.4 Citizen Registration Message

The citizen template is designed based on the HL7 patient registration template. The template contains the following segments:

- MSH Segment – This is the message header segment.
- EVN Segment – This is the event message segment.
- MID Segment – This contains the main data about the citizen. This segment uses the HL7 PID template for its data elements. MID -Member Identification.
- HID Segment – This segment links the citizen to a household. It derives its data elements from the HL7 PID template.
- XID Segment – This segment contains extra identifiers for the household data collection process. It contains the following data elements:
    - Team user details (unique identifier and name).
    - Team details (unique identifier and team name).
    - Service provider details (unique identifier and name).

Each of the above segments is of the same format as the Household Registration Message. In the next section, the specifics of a citizen as a member of a household are presented.

4.3.5 Citizen Triage

The citizen triage template is designed based on the HL7 patient observation template.

The template contains the following segments:

- MSH Segment – This is the message header segment.
- MID Segment – This links a citizen to the triage. This segment uses the HL7 PID

template for its data elements. MID - Member Identification.

- TID Segment - This segment contains the triage identifier. It derives its data elements from the HL7 PID data elements.
- HID Segment – This segment contains the household identifier linked to the citizen. It derives its data elements from the HL7 PID data elements.
- XID Segment – This segment contains extra identifiers for the citizen triage data collection process. It contains the following data elements:
    - Team user details (unique identifier and name).
    - Team details (unique identifier and team name).
    - Service provider details (unique identifier and name).
- ASR Segment – This segment contains the triage control results.
- ASX Segment – This segment contains the triage results. It derives its data elements from the HL7 Observation (OBX) data elements.

An alternative to using the custom MHI is to store household information using FHIR resources. To determine the most fitting FHIR resource for representing household information, considerations were given to the 'Group' and 'CareTeam' resources. Each resource offers unique features with the potential to represent households with varying degrees of complexity. The 'CareTeam' includes all the people and organisations who plan to participate in the coordination and delivery of care for a patient and the 'Group' resource represents a defined collection of entities that may be discussed or acted upon collectively but which are not expected to act collectively, and are not formally or legally recognised.

If we consider using the 'Group' resource to store information regarding a Household, we can add household members as 'Patient' references and use the 'Group.characteristic' element to identify what individuals can be part of a group.

The Group resource has the following structure:

- Identifier Element - A unique business identifier for this group.
- Active Element - Indicates whether the record for the group is available for use.
- Type Element - Identifies the broad classification of the group's resources.
- Actual Element - Should be set to true to indicate that the Group resource refers to a specific group of real individuals.
- Code Element - Provides a specific type of resource the group includes. e.g. *members*
- Name Element - A label assigned to the group for human identification and communication.
- Quantity Element - A count of the number of resource instances *(household members)*

that are part of the group.

- Managing Entity Element – The entity *(community health worker)* defines and maintains Group characteristics and/or registered members.
- Characteristic Element - A generic mechanism for identifying what individuals can be part of a group *(household)*.
- Exclude Element - If true, indicates the characteristic is one that members of the group do NOT hold.
- Period Element - The period over which the characteristic is tested.
- Member Element - Identifies the resource instances *(household members)* that are members of the group.

The 'Group.managingEntity' element can be used to identify the head of the household by referencing a 'RelatedPerson' resource. The 'RelatedPerson' resource also provides an 'address' element where the related person can be contacted or visited. The 'RelatedPerson' resource includes a 'RelatedPerson.relationship' element that can be used to store relation information regarding a patient and the related person. However, the latter poses a problem since the 'RelatedPerson.patient' element is required to reference a single patient. In our scenario, we have more than one patient in the household.

The 'RelatedPerson' *(Head of a household)* resource has the following structure:

- Identifier Element - Identifier for a person within a particular scope.
- Active Element - Indicates whether this related person record is in active use.
- Patient Element - The patient this person is related to. (This is, however, problematic because a household consists of many members).
- Relationship Element - The nature of the relationship between a patient and the related person. (This could have been used to indicate 'head of household' but is also problematic because a household consists of many members, and the standard refers to the relationship between a patient and the related person).
- Name Element - A name associated with the person.
- Telecom Element - A contact detail for the person, e.g. a telephone number or an email address.
- Gender Element - The gender that the person is considered to have for administration and record-keeping purposes.
- BirthDate Element - The date on which the related person was born.
- Address Element - Address where the related person can be contacted or visited.

- Photo Element - Image of the person.
- Period Element - The period of time during which this relationship is or was active. If there are no dates defined, then the interval is unknown.
- Communication Element - A language that may be used to communicate about the patient's health.

An alternative would be to consider using the 'Group.managingEntity' element to identify the community health worker assigned to a particular household by referencing a 'Practitioner' or 'Organisation' resource. In this case, we would still need to add a 'Location' resource as an 'Extension' to the 'Group' resource to store the address and contact information regarding the household.

The Patient Master Identity Registry (PMIR) Profile supports the creation, updating, and deprecating of patient master identity information about a subject of care, as well as subscribing to changes to the patient master identity, using the HL7 FHIR standard resources and RESTful transactions. In PMIR, *patient identity* information includes all details found in the FHIR Patient Resource, such as identifier, name, phone, gender, birth date, address, marital status, photo, others to contact, preference for language, general practitioner, and links to other instances of identities. The *patient master identity* is the dominant patient identity managed centrally among many participating organisations (a.k.a., *Golden Patient Identity*).

The PMIR Profile is intended for use in an environment where each patient has a single *Golden Patient record,* such as in Low- and Middle-Income Countries (LMIC). Beyond the basic create, retrieve, update, and delete transaction set, this profile addresses important patient safety issues related to cases where there are two or more patient master identities that have been established for the same person, thus it is not clear which identity is the *true* one.

To create, update, and deprecate master identity information about a household of care, one would also need profiles like the Patient Master Identity Registry (PMIR) Profile. A suggested new profile, namely the Household Master Identity Registry (HMIR) Profile, could be derived from the PMIR Profile. Like the PMIR Profile, the HMIR profile could find utility in environments where each household is associated with a single *Golden Household record.*

4.3.6 Message Transmission Architecture

The exchange of a message between the HIE and any third-party system involves several processes and protocols. Each process and protocol should conform to the required Integrating the Health Enterprise (IHE) profile. An IHE profile describes how a health-related message should be formed for integration to be ready. It defines how health standards can be implemented for seamless integration.

The flow of a message is based on the principle of Actors and Transactions.

An Actor is an information system that produces, manages and/or acts on information. An actor could be a Supplier or Consumer of information. For example, the third-party application platform is an actor that produces information for the HIE to consume.

The third-party application supplies household demographic messages to the HIE, as shown in Figure 4-1 below.

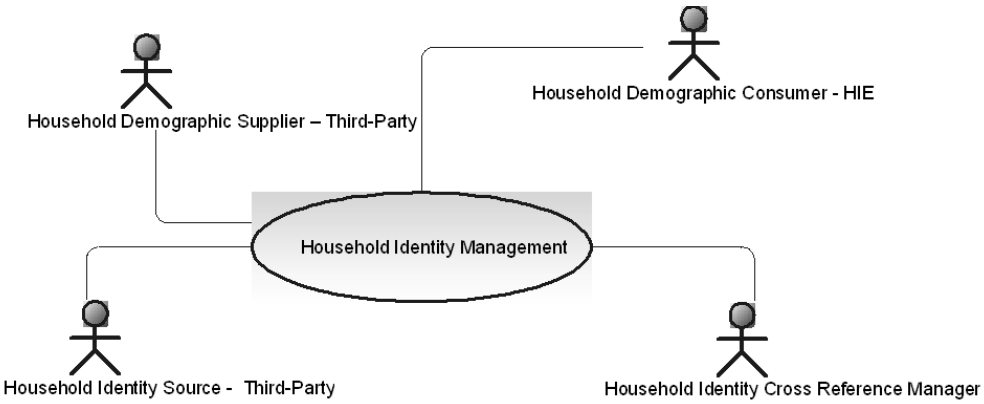

Figure 4-1: Household message Actors

The figure demonstrates the transmission of household triage to the CSIR MHI. The actors are the CHW database and the CSIR MHI. Any Household Demographic consuming system can assess the stored data by conforming to the associated customised HIE profile. In the case of this experiment, the CHW database is both the Household Demographic Supplier and the Household Identity Source. The Household Identity Management is the Household Identity Cross Reference Manager for any *Household Demographic Consumer* system.

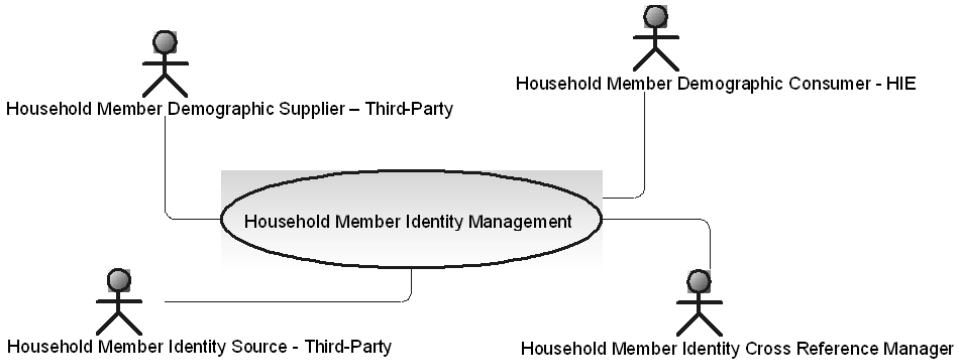

Figure 4-2: Household member message, Actors

Figure 4-2 demonstrates the transmission of household member triage from a third-party application (CHW) to the CSIR MHI. The actors are the CHW database and the CSIR MHI. Any Household Member Demographic consuming system can assess the stored data by conforming to the associated customised HIE profile. In the case of this experiment, the CHW database is both the Household Member Demographic Supplier and the Household Member Identity Source. The Household Member Identity Management is the Household Member Identity Cross Reference Manager for any Household Member Demographic Consumer system.

4.3.6.1 Trigger Events

A Trigger Event is a real-world event that generates a message and sends it to a consumer. For example, a patient's registration at a health facility can trigger a patient registration event by creating a message of type A05. Upon receiving the message, the Consumer (HIE) passes it for conformity to the message type template and processes it. It then sends an Acknowledgement (ACK) message to the Supplier due to processing the message.

The Event (EVN) segment of the message informs the Consumer application of the type of event and when it was triggered.

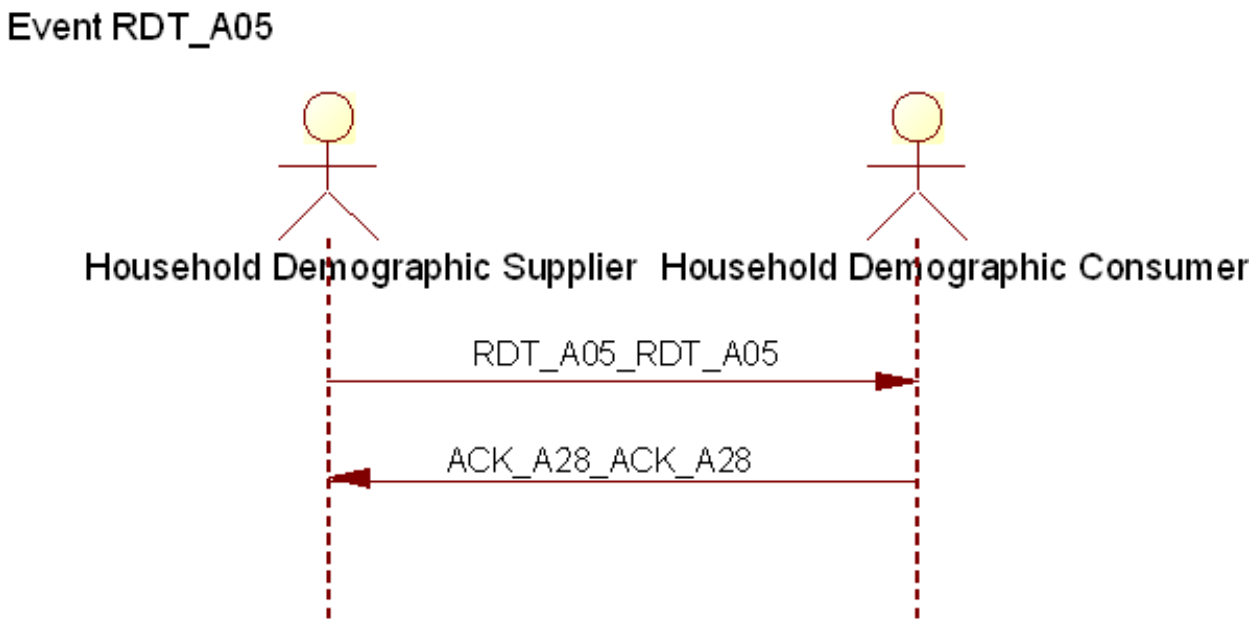

Figure 4-3: Event Process

Figure 4-3 demonstrates the type of event messages transmitted between the Household Demographic Supplier, the CHW database, and the Household Demographic Consumer, the CSIR MHI. The demographic supplier sends messages using the RDT (HL7 ADT) format and receives an acknowledgement from the demographic consumer using the HL7 ACK message format.

4.3.6.2 Response Events

Response events are triggered by the Consumer by a request from the Supplier. A Supplier Actor sending a patient registration event expects a response from the Consumer Actor regarding the successful or unsuccessful request. A Supplier Actor may also create a query event to request patient information.

4.3.7 FHIR mapping of a household

The Fast Healthcare Interoperability Resources (FHIR, HL7, 2023) has gained prominence for its structured data collection approach. However, challenges arise when extending its use to manage households of care. Examining various FHIR resources designed for communication reveals nuances in representing more than one 'subject of care' or household member. Resources like List, Group, CareTeam, Bundle, Composition, and the DomainResource.contained Element plays unique roles in managing collections of resources.

FHIR provides a structured approach to collecting patient data, but it falls short when it comes to linking records belonging to members of the same household. While exploring FHIR resources for household management, challenges arise, particularly in representing more than one 'subject of care' or member in a household. A closer look at several resources designed for communicating collections of resources in FHIR revealed the following (HL7 FHIR, 2024):

- List Resource: Enumerating a flat collection of resources, the List resource manages the dynamic addition and removal of items over time. It references other resources, providing curated and business-meaningful lists.
- Group Resource: Defining a group of specific entities, the Group resource is intended for actions or observations performed on the entire group. While suitable for public health and clinical trials, it lacks formal or legal recognition.
- CareTeam Resource: Distinct from the Group resource, CareTeam is patient-dependent and specific to a particular patient. It establishes relationships and roles, making it suitable for involving individuals in providing care.
- Bundle Resource: An infrastructure container for a group of resources, the Bundle resource groups collections of resources for transmission, persistence, or processing purposes.
- Composition Resource: Defining a set of healthcare-related information assembled into a single logical document, the Composition resource structures FHIR documents, referencing Lists for specific sections.
- DomainResource contained element: Allowing multiple resources to be nested inside any DomainResource, this element is a technical mechanism for managing the independence of resources, with no impact on meaning.

In exploring the standardising households through the FHIR standards, using the 'Group' resource to store household information involves adding household members as 'Patient' references and utilising the 'Group.characteristic' element to identify what individuals can be part of a group. However, challenges arise when referencing a 'RelatedPerson' resource in the 'Group.managingEntity' element, which is responsible for defining and maintaining the group characteristics and registered members necessitating referencing a single patient. Alternatives involve referencing a 'Practitioner' in the' Group. managing Entity' element to identify a community health worker. In addition, an extension holding a reference to a 'Location' resource would also be required to store the address and contact information regarding the household.

The *Patient Master Identity Registry* (PMIR) Profile, built upon HL7 FHIR standards, addresses patient identity management. It introduces the concept of a *Golden Patient Identity* managed centrally across participating organisations, ensuring consistency and patient safety. To extend this concept to households, a proposed Household Master Identity Registry (HMIR) Profile could be derived from the PMIR Profile. Like the PMIR, the HMIR profile would find utility in environments associating each household with a single *Golden Household record.*

In the next section, some related research initiatives and strategies are presented.

4.4 Alignment with the South African Digital Health Strategies

For the longest time before the COVID-19 pandemic, countries have been employing the concept of community health workers as a means to get healthcare services to remote areas [ref]. With the COVID-19 outbreak, where movements have been limited during the pandemic, the concept of Home-based Primary Care (HBPC) has become prevalent (Leff et al., 2022; Ritchie et al., 2021). Though it existed before and initially aimed at homebound patients such as the elderly patients, it became more prevalent during the height of the pandemic as a larger population movement became limited and health care service that allowed it needed to be received remotely. In both cases, community health workers play a significant role in enabling the programmes and improving their efficiency.

One of the priorities in the national digital health strategy values community-based interventions that allow the expansion of primary health promotion coverage (Department of Health, 2019). The community-based interventions are still relevant as they allow primary care services to reach a wider population. The need to standardise mobile health support systems is also important, and this chapter addresses the need.

The standardisation in the current approach focuses on the message formats and message exchange protocols to allow integration of the household or home-based system with main healthcare systems via health information exchange systems. An approach based on the HL7v2 standards was proposed by Sibiya et al. (Sibiya et al., 2017). The current approach takes advantage of the developments in FHIR standards (HL7, 2023).

In the next section, the benefits related to the end, which includes community healthcare workers, are presented.

4.5 Benefits and Challenges

This investigation revealed that the household of care can be represented and managed following HL7-based interoperability standards. This was experimented with by implementing existing tools developed for a Master Patient Index (MPI), the open-source Extensible Master Patient Index (OpenEMPI, 2023). The findings are that through the implementation of the proposed standard format, the household of care could be indexed as it could be done equivalently for patients of care.

This can add value to a contact tracing process, as it proved necessary during the COVID-19 pandemic.

The FHIR standards-based approach proposed in this chapter will enable interoperability with a broader range of health systems that already exist at a national level and those that are yet to be procured or developed.

4.6 User Perspective

This section presents benefits to end users, including community health providers. In South Africa, when community health care workers are assigned, they are provided with tools, including mobile devices with applications for collecting the information. The applications often work offline, and captured information is uploaded to central servers once they are online. In a client-server model, various mobile applications collect and upload information to a central server. The mobile client and server are often tightly coupled and cannot interoperate with external systems. Through its SMART guidelines initiative, the WHO develops tools that will be embedded into mobile applications software development kits (SDKs) (WHO, 2021). The approach presented in this study leverages the initiative and presents a way to represent households as also subjects of care and represent and transmit their data in a FHIR standards format. This will allow community health workers to exchange their collected household data with national systems regardless of the software product they chose or were assigned.

In the next section, considerations for the implementation of a household of care.

4.7 Implementation Guidance

This section presents requirements for implementing a FHIR-based Master Household Index. The considerations are grouped into technology, stands, end users, budget, timeline, and required resources. The outcomes are based on experiments conducted.

4.7.1 Technology

The proposed concept has only been implemented and experimented on in the HL7v2 approach. For an implementation that can be integrated with the latest technologies, the FHIR version-based interoperability standards need to be considered. Open-source technologies that implement the FHIR standards can be reused for the Master Household Index. The open-source tools include HAPI tools (HAPI-FHIR, 2022). Another open-source tool bundle is in LinuxForHealth operating system (Linux for Health, 2020). The operating system consists of the latest components contributed by the community. Some examples of a component native to the operating systems area a FHIR server and connection, routing and health service billing services. Through its SMART guidelines initiative, the WHO has tools that are being developed for member states to reuse in their digital health transformation.

4.7.2 Relevant Standards

The HNSF prescribes the base standards for implementation. The FHIR specifications can be adapted to support the message presented in section 4.3. The infrastructure to create, transmit, exchange and store the messages comprises technologies presented in section 4.7.1.

4.7.3 End-User Considerations

The primary end users expected to benefit from the implementation of the FHIR-based household care are community health workers. Use cases aimed at community health workers can be used to model functional requirements.

4.7.4 Budget and Timeline

The budget will be closely linked to the resources committed to the implementation task. This includes human resources and the hosting infrastructure. The timeframe to develop and implement the concept can be no longer than three years.

4.8 Findings and Analysis

The work presented in this chapter demonstrated the ability to leverage the existing interoperability standards to support household care management. This chapter's proof of concept was only implemented at an experimental stage. It still needs to be implemented in practice as per the guidance provided in Section 4.7. This will provide an opportunity for further improvements in the efficiency and quality of the proposed concept.

4.9 Conclusion and Future Work

As FHIR continues to revolutionise data exchange in healthcare, its application in managing households of care introduces challenges that demand innovative solutions. The exploration of

resources like 'Group' and 'CareTeam', coupled with the proposed HMIR Profile, paves the way for a more comprehensive representation of household data within the FHIR framework. The evolution of FHIR standards and developing specialised profiles, demonstrate the ongoing commitment to enhancing healthcare data interoperability and patient identity management.

Glossary

- ACK – Acknowledgement
- Actor – Information system or components of information systems that produce, manage, or actor on health information. Actors exchange information through standards-based transactions (IHE, 2023).
- ADT – Admit, Discharge and Transfer1.
- AID – Assessment Identifier. This is a variant of PID (Patient Identifier as defined by HL7)
- Assessment – Collection of social data.
- ASR – Assessment Record. This is a variant of OBR (Observation Record as defined by HL7)
- ASX – Assessment Results. This segment contains the results of the assessment in a coded form. This is a variant of OBX (Observation Result segment as defined by HL7)
- Citizen – An individual belonging to a household.
- HID – Household Identifier. This is a variant of PID (Patient Identifier as defined by HL7).
- HIE – Health Information Exchange.
- HL7 – Heaven Level Seven International. An international standards development organisation in the domain of healthcare information exchange (HL7, 2011).
- HNSF – Health Normative Standards Framework.
- HOUSEHOLD – A geographical location of people belonging to a family and sharing common facilities.

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Chapter 5: The Transformative Impact of Electronic Prescriptions: Enhancing Patient Care and Healthcare Efficiency

Munsamy, S.[1], Underwood, S.[2], Labadarios, G.[2], Ramsundar, P.[1], Sha, M.[2], Botha, A.[1] and Herselman, M.[1]

[1]Next Generation Enterprises and Institutions (NGEI) cluster, Council for Scientific and Industrial Research (CSIR), Pretoria, South Africa; [2] National Department of Health

Purpose: *This chapter provides an overview of what constitutes the transformative impact of ePrescribing in enhancing patient care and healthcare efficiency by defining the concept and providing its value chain and ecosystem. It aims to synthesise key findings and insights to offer meaningful suggestions further to form the groundwork for a National South African Implementation.*

Study design/methodology/approach: *This chapter applied a qualitative exploratory approach to study relevant literature on the phenomena of ePrescribing. Using this method, one can map the existing knowledge of the phenomena and identify gaps the studies address. Document and thematic analysis were used to examine and interpret data from the selected articles to uncover meaning, gain understanding, and conclude. Understanding this concept's challenges, building blocks, design elements, and realities will add to its applicability within an African context.*

Originality/value: *By leveraging digital technology, ePrescribing systems can give clinicians real-time access to patient medication histories, drug interactions, and formulary information, enabling them to make more informed and safer prescribing decisions. It conceptualises ePrescription, highlighting possible challenges and opportunities within the emerging South African Health Information system.*

Findings: *Electronic prescribing, or ePrescribing, has gained significant traction in recent years, potentially improving the efficiency and accuracy of the prescribing process in ambulatory care settings*

Keywords: *ePrescribing, ePrescription, capabilities and requirements, lesson learned, South Africa*

5.1 Introduction

In the ever-evolving healthcare landscape, adopting electronic prescriptions (ePrescriptions) has emerged as a transformative force, reshaping how patients receive and manage their medications (Oktarlina, 2020; Porterfield et al., 2014). Electronic prescribing (ePrescribing) is an integral component of a health information technology system and a required component of the 'meaningful use' of health information technology (Bilgener & Bulut, 2021). ePrescribing has the potential to improve the safety, quality, and efficiency of healthcare as well as reduce medication costs (ePrescribing (eRx), 2023)(Stoumpos et al., 2023).

One of the primary benefits of ePrescribing is its ability to reduce the risk of prescribing errors, which have been identified as the largest source of preventable errors in hospitals (Dastani & Atarodi, 2022).

ePrescribing (electronic prescribing) is a value-laden term seemingly interpreted in various ways to outline using electronic systems to generate and transmit prescriptions to improve healthcare services' efficiency, accuracy, and overall quality. The academic articles published have steadily peaked over COVID-19 as this was prioritised. While the potential benefits of ePrescribing are widely recognised, adopting and implementing these systems have faced various challenges and limitations (Hahn & Lovett, 2014).

Building on the existing body of academic literature, this paper aims to synthesise key findings and insights to offer meaningful suggestions that can further form the groundwork towards a National South African Implementation. This chapter will provide an overview of the definitions, focusing on its value chain, eDispensing system, and associated processes. International perspectives and examples and a local case study are provided. The requirements and classes of an ePrescription system are also investigated. Challenges and lessons learned are shared.

5.2 Methodology

The methodology followed a qualitative exploratory study in which relevant literature reviews were conducted from 2015 to 2024 (Nor, 2020). An exploratory qualitative study is a foundational research approach that investigates phenomena, identifies themes and patterns, and generates hypotheses for future research (Olukiun et al., 2021; Yadav, 2021). In analysing the phenomena of ePrescribing, the researcher can leverage insights from authors in research papers (Prasantham, 2023; Ragab & Arisha, 2017). In using this method, one can map the existing knowledge of the phenomena and identify gaps that the studies address (Fernandez, 2020; Olukiun et al., 2021; Prajapati et al., 2015). Document analysis will also examine examples of papers and identify best practices. Document analysis is the process of reviewing or evaluating documents, both printed and electronic, in a systematic manner (Sandelowski, 2010). Like many other qualitative research methods, document analysis involves examining and interpreting data to uncover meaning, gain understanding, and conclude. Thematic analysis was undertaken using the method described as

fundamental or generic qualitative description, which aims to discover and understand a phenomenon (or the perspectives of people involved) with themes generated from the reviewed literature (Sandelowski, 2010). Following the general principles of qualitative data analysis and to establish reliability, the authors first familiarised themselves with the data by reading through the selected articles and reflecting on them using margin notes, entering the critical findings in tables, and then counting the number of key findings to generate initial themes to compare so that the analysis was interactive (Sandelowski, 2000). Open discussions were held with all authors of this paper to refine and re-conceptualise themes until reaching a consensus.

The findings from this study were critically analysed and discussed concerning the initial research problem and the extant literature. This analytical process is instrumental in generating meaningful insights and delineating the practical and theoretical implications of the research (Abdulai & Owusu-Ansah, 2014; McMeekin et al., 2020).

5.3 Overview of Literature on ePrescribing

As was already indicated, papers on ePrescribing peaked during and after COVID-19. The following figure outlines the most significant years (2020-2021) in which most papers were written on the concept.

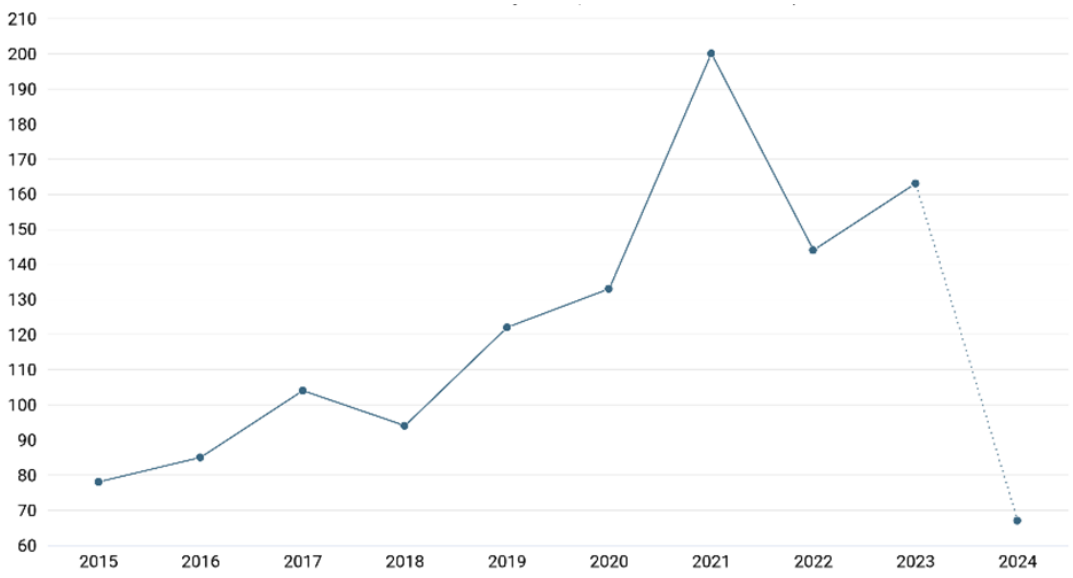

Figure 5-1: Publication on e-prescription

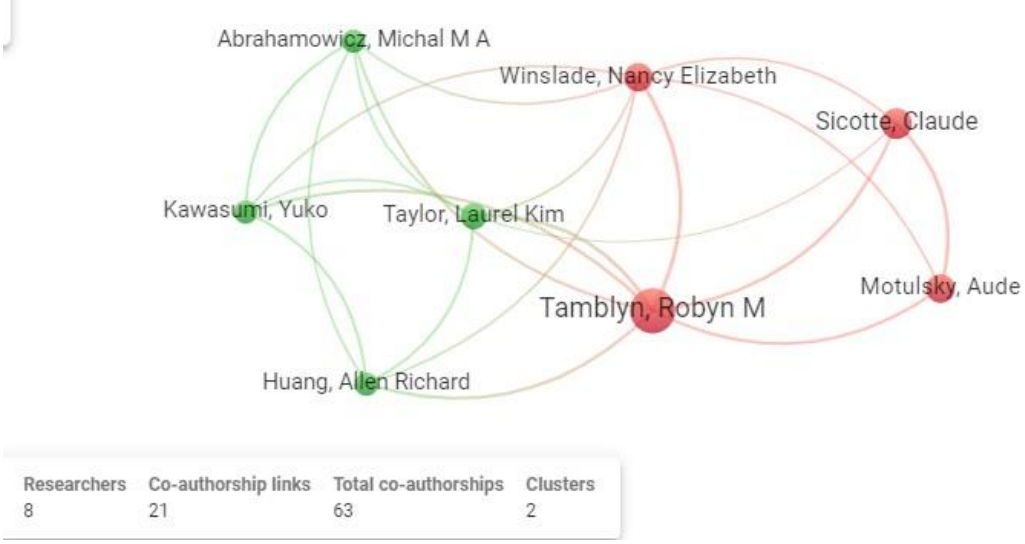

Figure 5-2: Researchers who mostly write on the topic

The visual representation above of the co-authorship network illustrates the collaborative relationships between eight researchers in ePrescription. The network is segmented into two clusters, indicating groups of researchers who have closely worked together on various publications. The 8 Researchers have 21 co-authorship links and have co-authored 63 times.

Research Trends indicate High Volume versus High Impact: Journals like the European Journal of Hospital Pharmacy have many publications, suggesting a broad interest and active research community. In contrast, despite fewer publications, journals like JAMIA have a higher impact, highlighting groundbreaking or foundational research.

Some journals focus on specific aspects of ePrescription, such as paediatric applications (Archives of Disease in Childhood) or integrated care (International Journal of Integrated Care), indicating specialised research niches.

This outline aims to review the current state of ePrescribing, examining its cost-effectiveness, clinician adoption, and the limitations that have hindered its widespread implementation.

5.4 Defining of ePrescription

Definitions can be categorised into several types, each serving a unique purpose. A formal definition provides a precise meaning using concise and specific terms, while an operational definition describes how something works or is measured. Stipulative definitions assign a meaning to a term for the first time, and lexical definitions explain how a term is commonly used in language. Persuasive definitions aim to influence attitudes or emotions, and ostensive definitions clarify a term by pointing to examples. Genus-differentia definitions specify a term by its general

category and distinguishing features, whereas contextual definitions elucidate a term by using it within a particular context (ISO, 2022; Sager, 1990).

In ePrescription, the definitions vary significantly due to the diverse technological, regulatory, and practical frameworks across different regions and healthcare systems. This variance underscores the need to develop a common language to ensure consistency, improve understanding, and align the conversations around this. Given the complexity and multifaceted nature of ePrescription, it becomes essential to recognise the different ways this concept can be interpreted and applied. The implications of how ePrescription is defined can significantly impact its implementation and functionality. In this regard, the following variance in definitions are noted, each providing a perspective on what ePrescription entails and suggesting implications when integrating it into the health information system (Friedman et al., 2009; Hahn & Lovett, 2014; Maria et al., 2009; Dastani & Atarodi, 2022; Zadeh & Tremblay, 2016):

- ePrescription, also known as electronic prescribing (ePrescribing), is a process where healthcare providers use electronic devices to generate, transmit, and receive prescription information securely and efficiently (Hahn & Lovett, 2014; Dastani & Atarodi, 2022).
- Prescribing medicines using software by an authorised entity for dispensing in a pharmacy (Aldughayfiq & Sampalli, 2021; Dastani & Atarodi, 2022).
- Using an electronic device to submit and exchange prescription information among patients, prescribers, and pharmacies (Goundrey-Smith, 2008).
- Direct computer-to-computer transmission of e-prescriptions from prescriber offices to community pharmacies (Dastani & Atarodi, 2022).
- A digital version of a paper prescription using an electronic device to submit and exchange medication information.(Farghali et al., 2021; Hahn & Lovett, 2014; Spiro & Saxton, 2005).
- Electronically generate and send a prescription order to transmit an electronic prescription.(Aldughayfiq & Sampalli, 2021; Farghali et al., 2021; George et al., 2011; Oktarlina, 2020; Zadeh & Tremblay, 2016; Zemene et al., 2022).
- The transmission of prescription information between prescriber, dispenser, pharmacy benefit manager, or health plan is done using electronic media (Zemene et al., 2022).

A universal definition of ePrescribing is not noted at the time of publishing.

With regards to South Africa, the Announcements, Tabling and Committee Reports (2019), under Programme 2: Legal, Authorisations, Compliance and Enforcement, mentions the Implementation of the automated ePrescription and eDispensing system at 25 health facilities (Announcements, Tablings and Committee Reports, 2019, p. 257/341). Further, it alludes to the ability to Implement the early warning system for medicine stockouts in partnership with users and patient groups, which alludes to an additional stock management system.

The differentiation between an ePrescription and eDispensing system is again reiterated by the NDoH (2020) in The Digital Health Strategy, where inference is made to an ePrescription system that includes a *clinical decision support system and an electronic medicine catalogue* (NDoH, 2019, 257/341).

As such, a clear definition for ePrescription is not only suggested, but a clear demarcation of the ePrescription System is also needed to scope, cost, and conceptualise the realisation of ePrescriptions.

The following definition is suggested:

ePrescription is defined as the electronic prescribing of medicine with the use of software and the electronic transmission of said prescription data to a pharmacy where the medicine can then be dispensed (Aldughayfiq & Sampalli, 2021; Digital Health Europe, 2020; Farghali et al., 202;1 George et al., 2011; Oktarlina, 2020; Samadbeik et al., 2013; Zadeh & Tremblay, 2016; Zemene et al., 2022

Various interpretations of ePrescription also need consideration.

5.5 Interpretations of Using ePrescribing

The following table summarises the interpretations, definitions, implications and references linked to these uses of ePrescribing.

Table 5-1: ePrescribing Interpretations and Implications

Interpretation	Definition	Implications	Reference
ePrescribing as a Method	A systematic approach to generating and sending prescription orders electronically.	Focuses on the structured methodology and protocols involved in ePrescription, highlighting efficiency and accuracy.	EPrescribing enables a prescriber to electronically send an accurate, error-free and understandable prescription directly to a pharmacy from the point of care (CMS, 2024, June 06).
ePrescribing as a Process	The sequence of steps involved in creating, transmitting, and fulfilling electronic prescriptions.	Emphasises workflow optimisation, from prescription generation to reception and processing by pharmacies.	Electronic prescribing or ePrescription refers to a process by which prescription information is created electronically (WA Gov, 2022).
ePrescribing as an Artifact	The digital representation of a prescription.	Focuses on data integrity, security, and interoperability of electronic prescriptions.	ePrescribing has been defined as the computer-based electronic generation, transmission, and filling of a prescription (Porterfield et al., 2014).
ePrescribing as a Program	The software or platform used to create and manage electronic prescriptions.	Highlights the technological infrastructure, user interface, features, and capabilities of ePrescription systems.	ePrescribing (eRx) is the electronic transmission of a drug prescription directly to a pharmacy through EHR technology (American Psychiatric Association, n.d).

Interpretation	Definition	Implications	Reference
ePrescribing as an Action	The act of generating and sending a prescription electronically by a healthcare provider.	Stresses healthcare providers' behaviour and practices, including ease of use and clinical impacts.	Simply put, electronic prescribing, or ePrescribing is a method of prescription transaction that allows prescribers to write and send information (DoseSpot, 2017).
ePrescribing as a Policy	Regulatory frameworks and guidelines governing the use of electronic prescriptions.	Focuses on compliance, legal considerations, and the role of regulatory bodies.	EPrescribing uses healthcare technology to improve prescription accuracy, increase patient safety, reduce costs, and enable security (AMCP, 2019).
ePrescribing as a Component	An integral part of broader health IT ecosystems, including electronic health records (EHRs).	Highlights integration and interoperability with other digital health tools.	ePrescribing is a system that facilitates the interaction between physicians and pharmacies by enabling physicians to create and pass on prescriptions (Zadeh & Tremblay, 2016).
ePrescribing as a Driver	A catalyst for transforming healthcare delivery and improving medication management.	Emphasizes enhancing patient safety, reducing medication errors, and streamlining processes.	Electronic prescribing allows prescribers to send your prescriptions directly to your pharmacy. Electronic prescribing can save you money and time (Medicare, n.d).
ePrescribing as a Data Source	A repository of prescription data that can be analyzed for insights.	Focuses on data analytics, research, and population health management.	ePrescribing is a meaningful way of using EHRs because technology is used to enhance the quality of patient care. Allowing providers to access patient histories, diagnoses, and medication information increases patient safety by reducing medical errors (Porterfield et al., 2014).
ePrescribing as a Service	A service provided by healthcare institutions or third-party vendors to facilitate electronic prescriptions.	Considers customer support, service quality, and business models behind ePrescription services.	The EPrescriptionService (EPS) allows prescribers to send prescriptions electronically to a dispenser, such as a pharmacy (NHS England, 2023, January 6).
ePrescribing as a Value Chain	A series of integrated processes and activities within the healthcare system that enhance the accuracy, efficiency, and safety of medication prescribing and dispensing through technology	Optimising each stage of the prescription process to improve patient outcomes, streamline healthcare workflows, and ensure seamless technology integration across the healthcare system.	Why ePrescription? EPrescribing creates a real-time, unbroken value chain and alters the end-of-consultation discussion to show the value chain impact (Tremblay, 2003).

These varied interpretations of ePrescription illustrate this healthcare innovation's complex and multifaceted nature. As the adoption of ePrescription continues to grow, it will be crucial to establish a shared understanding and language to align the conversations, research, and implementation efforts around this critical digital health component (George et al., 2011; Porterfield et al., 2014).

ePrescription also functions within an ecosystem.

5.6 The Ecosystem of ePrescription

Considering the implications, it is desirable to indicate that ePrescription is not only a phenomenon, but also the ecosystem in which it functions and how its value chain fits into this ecosystem (Hahn & Lovett, 2014; Dastani & Atarodi, 2022). The following figure summarises how ePrescription fits into the different ecosystem levels and the associated stakeholders/bodies/facilities linked to each level.

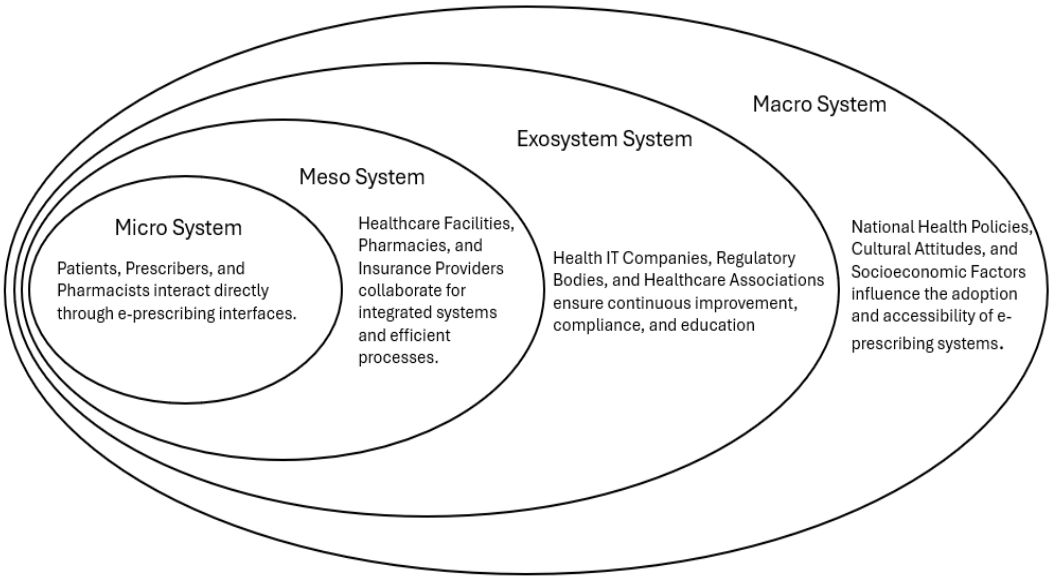

Figure 5-3: Bronfenbrenner perspective on the ePrescribing Ecosystem (Pereira et al., 2018)

Bronfenbrenner's ecological systems theory describes how various environmental layers influence an individual's development (Bronfenbrenner's Exosystem: Definition & Examples, 2021; Paquette & Ryan, 2001). In this diagram, four concentric circles represent different systems interacting in the context of ePrescribing: Microsystem, Mesosystem, Exosystem, and Macrosystem (Pereira et al., 2018).

- The microsystem represents the direct interactions between the healthcare provider and patient in the ePrescription process.
- The mesosystem describes the inter-relationships and linkages between healthcare stakeholders, such as providers, pharmacies, and insurance/reimbursement entities.
- The Exosystem encompasses the broader technological, regulatory, and organisational infrastructure that supports ePrescribing.

- The macrosystem refers to the overarching societal, cultural, and economic factors that shape the ePrescribing landscape.(Farghali et al., 2021; Zadeh & Tremblay, 2016).

Table 5-2: The ecosystem levels with its associated actors and their interactions at each level

	Actors	Interactions
Microsystem	Patients, Prescribers (Doctors, Nurses), Pharmacists	Patients interact with prescribers to receive medical consultations and prescriptions. Prescribers use ePrescribing systems to generate and transmit prescriptions. Pharmacists receive electronic prescriptions, dispense medications, and provide counselling to patients.
Mesosystem	Healthcare Facilities, Pharmacies, Insurance Providers	Healthcare facilities ensure that prescribers have access to ePrescribing systems and proper training. Pharmacies integrate e-dispensing systems to manage electronic prescriptions efficiently. Insurance providers interact with healthcare facilities and pharmacies to streamline prescription coverage and reimbursement processes.
Exosystem	Health IT Companies, Regulatory Bodies, Healthcare Associations	Health IT companies develop and maintain ePrescribing software and infrastructure. Regulatory bodies set standards, guidelines, and compliance requirements for ePrescribing systems. Healthcare associations advocate for best practices, provide training, and support the adoption of ePrescribing technologies.
Macrosystem	National Health Policies, Cultural Attitudes, Socioeconomic Factors	National health policies promote the adoption and standardisation of ePrescribing systems nationwide. The cultural attitudes towards the technology of patients and healthcare providers influence the acceptance and usage of ePrescribing systems by patients and healthcare providers. Socioeconomic factors determine the accessibility and affordability of ePrescribing technologies and healthcare services.
Chronosystem	Technological Advancements, Policy Changes, Longitudinal Studies	Technological advancements continuously improve ePrescribing systems, making them more user-friendly and secure. Policy changes adapt to new healthcare needs, ensuring that ePrescribing systems remain relevant and effective. Longitudinal studies track the impact of ePrescribing systems on healthcare outcomes over time, providing data for further improvements.

This ecological systems framework provides a comprehensive perspective on the multifaceted nature of ePrescribing and the various interconnected layers that impact its implementation and effectiveness (Grossman et al., 2007).

ePrescription also functions within various contexts.

5.7 ePrescription in Context

As indicated in the above section, ePrescribing functions within a larger digital health ecosystem. According to the literature, the benefits of e-prescriptions can be realised when integrated with electronic health records (EHRs) and pharmacy management systems (Hahn & Lovett, 2014). The researchers developed the following figure to illustrate the relationships (in context) between the ePrescription Value Chain, ePrescription system, and eDispensing system:

The processes involved in the first two sections at the beginning of Figure 5-4 will now be explained.

5.7.1 ePrescription Value Chain (ePrescription Process)

The ePrescription process involves three main steps (Hahn & Lovett, 2014; Dastani & Atarodi, 2022; Samadbeik et al., 2013):

- ePrescribing: The prescriber generates an electronic prescription.
- Electronic Transfer of Prescription (ETP): The ePrescription list is transmitted to the dispenser.
- eDispensing: The dispenser retrieves and dispenses the medication as per the electronic prescription.

5.7.2 ePrescription System

The ePrescription system encompasses the technology and infrastructure required to facilitate the ePrescribing process, including:

- The secure generation and transmission of electronic prescriptions (Aldughayfiq & Sampalli, 2021; Goundrey-Smith, 2008).
- The clinical decision support to guide safer prescribing (NHS England, 2023, February 6; Vejdani et al., 2022).
- The integration with electronic health record (EHR) systems (Aldughayfiq & Sampalli, 2021; Goundrey-Smith, 2008).
- Compliance with National regulations and guidelines (Aldughayfiq & Sampalli, 2021; Goundrey-Smith, 2008).

- Interoperability with pharmacy management systems (Dastani & Atarodi, 2022; Hahn & Lovett, 2014; Samadbeik et al., 2013).

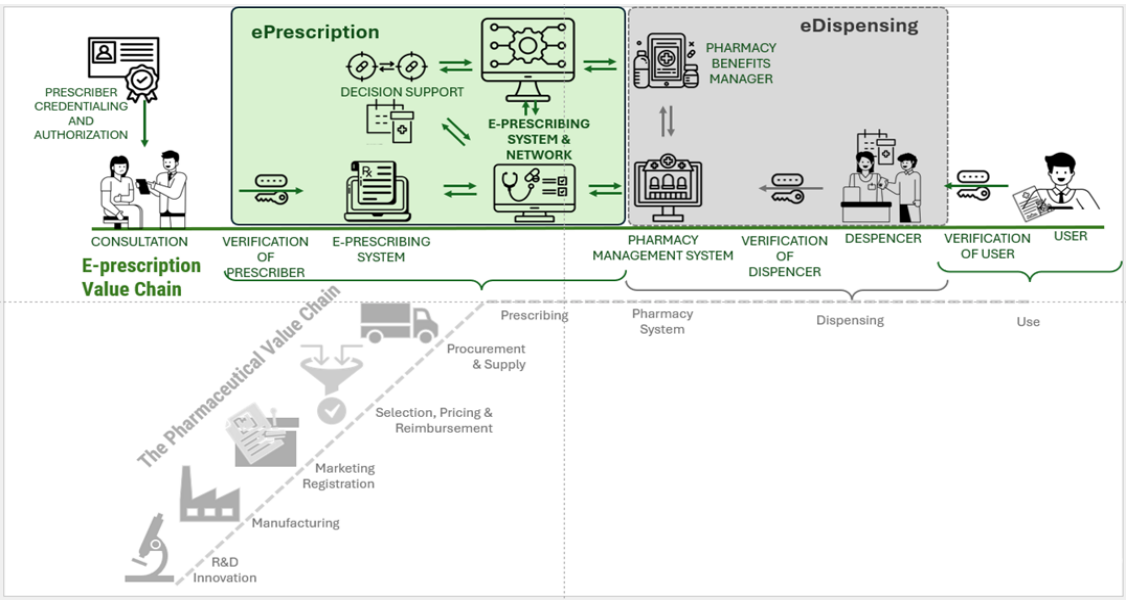

Figure 5-4: ePrescription within the context of EHR and pharmacy management systems (Hahn & Lovett, 2014)

5.7.3 eDispensing System

The eDispensing system refers to the technology and processes within the pharmacy to receive, verify, and dispense medications as per the electronic prescription (Aldughayfiq & Sampalli, 2021; Goundrey-Smith, 2008; Vejdani et al., 2022). It involves the following processes:

- EPrescription retrieval is done by the pharmacy (Aslam, 2012; Pennebaker & Campbell, 1988).
- Verification of the prescription details (Samadbeik et al., 2013).
- Medication dispensing as per the electronic instructions (George et al., 2011; Hahn & Lovett, 2014).
- Recording of the dispensation event in the pharmacy system (Dastani & Atarodi, 2022).
- It is optional to report back to the prescriber and national health authorities on the dispensed medication (Patrão et al., 2013; Vejdani et al., 2022; Zadeh & Tremblay, 2016; Omotosho et al., 2017).
- Ensuring compliance with regulations and guidelines (Zadeh & Tremblay, 2016).

5.7.4 Relationship between ePrescription process, ePrescription system, and eDispensing

The ePrescription process, ePrescription and eDispencing systems relate to one another through:

- Integration and Interoperability: The ePrescription system integrates the ePrescribing and eDispensing processes through a secure ePrescriptiontransfer. Interoperability with national eHealth services ensures that prescriptions are accessible across different healthcare providers (Brennan et al., 2015; King et al., 2007).
- Security and Compliance: The ePrescription system ensures that all steps in the ePrescription process comply with national standards and regulations, including secure transmission and electronic signatures. It maintains the integrity and confidentiality of prescription data throughout the process (Vejdani et al., 2022).
- Quality and Safety: The ePrescription system incorporates clinical decision support to guide safer prescribing and reduce medication errors (Datani & Atarodi, 2022).
- Efficiency and Accuracy: By automating the prescription generation, transfer, and dispensing, the ePrescription system reduces errors associated with handwritten prescriptions. It enhances efficiency in both prescribing and dispensing, ensuring timely access to medications for users/patients.(Hahn & Lovett, 2014; Samadbeik et al., 2013).

Apart from the ePrescription in contexts and its relation to the ePrescription and eDispensing systems, it is also imperative to understand the ePrescription value chain system requirements.

5.8 ePrescription Value Chain System Requirements

Inefficiencies, fraud, and administrative burdens associated with paper-based prescribing systems can be addressed effectively with ePrescribing (Ahmadi et al., 2017). ePrescribing extends beyond merely utilising a computer for prescription writing and storage. With specialised software and internet platforms (Shi et al., 2018), the technology facilitates all stages of the prescription process, such as identifying patients, registering prescriptions, revising prescriptions, duplicating and renewing prescriptions, and transferring prescriptions among stakeholders. A discussion of these requirements will follow after the following figure.

According to Vejdani et al. (2022), the following needs should be addressed while developing an ePrescription system:

Patient data, Patient selection or identification and data access, Drug Selection, Security, Privacy and administration, Transparency and accountability, Interoperability and communication, Monitoring, report, reminder, and renewals, Feedback at the prescriber level, Infrastructure: Computer equipment, Awareness of physicians and System support, Patient education and information, Usability, Standards, History of Medications / Current Medications, Data transfer and

storage, Alerts and other messages to prescribers, and filtering of user-selectable alerts for possible prescription problems and Decision support (see Figure 5-5).

Figure 5-5: Recommended system requirements for improving the ePrescription system (Adapted from Vejdani et al., 2022)

The following requirements were identified:

- Patient identification is usually the first step of electronic prescribing (Hailiye et al., 2022). Prescribers often make mistakes when choosing from menus and, as a result, inadvertently select the wrong patient. Errors are reduced when there is a detection and correction system (Terzi & Stamelos, 2024). Since reducing errors in the ePrescriptionsystem is one of the main advantages of this system, the correct identification of the patient is one of the main requirements.
- Safety alerts and filtering user-selectable alerts for possible prescribing problems (Vejdani et al., 2022). System safety alarms dramatically reduce allergy errors and drug selection; therefore, the adequacy of system alerts should be considered one of the main requirements

(Pereira et al., 2018).

- Computer-assisted dose calculations can increase prescribing accuracy (Western Australia Government, 2022). However, appropriate calculations require ePrescription systems to access medical records data such as age, weight, BMI, and laboratory results that reflect renal and hepatic function Vejdani et al., 2022).
- Data transfer and storage were identified as a recommendation for improving ePrescribing systems. Transmitting data electronically from prescribing systems to pharmacies led to eliminating human transcription errors and improving safety and efficiency (Vejdani et al., 2022). However, errors or physician work might increase if transmissions are unreliable or prescribing data is entered manually at the pharmacy (Omotosho et al., 2017). Proper data transfer to the pharmacy instead of the prescription being written by the physician is necessary, especially in countries that have recently adopted an ePrescribing system (Vejdani et al., 2022).
- Providing infrastructures, such as computer equipment, system support, patient education, information, and user education, were identified as features of the ePrescription system (Vejdani et al., 2022). Well-designed training materials can reduce outpatient errors (Mohsin-Shaikh et al., 2019). The systems facilitating physician-nurse-pharmacist collaboration in patient education can increase compliance (Virk et al., 2006). Unfortunately, in developing countries, because of users' resistance to change, their educability is affected. On the other hand, the low speed of the national Internet in such communities is one of the underlying causes of the failure of projects (Samadbeik et al., 2022). Therefore, much attention to the main infrastructure of this system is crucial.
- The scoping review of Vejdani et al. (2022) cited prescriber input as a guideline for enhancing ePrescription systems. Prescription systems with access to pharmacy data may alert doctors when patients fail to complete prescriptions on time, allowing physicians to probe patient non-compliance (Hailiye et al., 2022). Numerous computerised tools, like reminders, feedback, treatment suggestions, and patient care based on established protocols, may help physicians improve their prescriptions if they are incapable of doing this (Terzi & Stamelos, 2024).
- Data security and confidentiality were identified as the key requirements in implementing ePrescription systems. Security and privacy are two key challenges that electronic health systems face (Vejdani et al., 2022). Medical data security can be controlled easily by healthcare organisations; however, if medical data is to be transmitted to some other healthcare institution, then some third party may compromise the security and privacy of medical data (Terzi & Stamelos, 2024). There is no doubt that patient privacy is necessary, but the emergence of various applications that help users implement ePrescribing better should be cautious and comply with legal issues (Soceanu et al., 2015).
- Drug selection and the history of current drugs should be precise and clear, and the system

should include patient follow-up about previously prescribed medications (Mohsin-Shaikh et al., 2019). The physician's knowledge of the patient's medical history, especially for chronic or special patients, is essential.

- Decision support in ePrescribing systems can provide physicians or patients with clinical knowledge and, if presented at appropriate times, can improve the safety, quality, efficiency, and cost-effectiveness of care (Omotosho et al., 2017). Decision support seems to act as a double-edged sword because, on the one hand, it guides and helps the doctor in making decisions; on the other hand, it confronts the doctor with limitations. In other words, the support system influences the physician's decision, and he cannot diagnose and treat independently (Vejdani et al., 2022).
- Transparency and accountability can prevent third parties from introducing prescribing biases that would not benefit patients because vendors can substantially influence prescribing decisions (Canada Health Infoway, 2019).
- The standards were also indicated in the above figure as necessary. Formulary and Benefit (F&B) standards provide data for drug insurance benefits plans as opposed to data about individual patients, which is necessary to enable the display of coverage information for each medication in the pick lists that prescribers use to make initial medication choices (Vejdani et al., 2022). The SCRIPT standard provides prescribers with information about patients' current and past medications by listing the pharmacy claims the patients' health plans have paid for (Terzi & Stamelos, 2024). SureScripts (2019) enforces this standard by listing drug purchases that exceed what is paid for by insurance. RxNorm standard is a drug nomenclature created by the National Library of Medicine to standardise the representation of clinical drugs, distinguishing drugs based on their therapeutic or diagnostic intent (Australian Digital Health Agency, 2020; NHS England, 2023, May 15).

Based on the above discussion on system requirements, the ePrescription value chain system requirements are depicted in the following figure. From this figure, the most important part of the process in the value chain is the prescriber credentials and authorisation of patients when they visit the pharmacy. These outlines do not possible alerts for chronic disease management, and the figures were developed by the researchers based on the literature reviews (Vejdani et al., 2022; Hailiye et al., 2022; Mohsin-Shaikh et al., 2019; Omotosho et al., 2017; Pereira et al., 2018; Terzi & Stamelos, 2024; Virk et al., 2006; Canada Health Infoway, 2019, Western Australian Government, 2022; Soceanu et al., 2015).

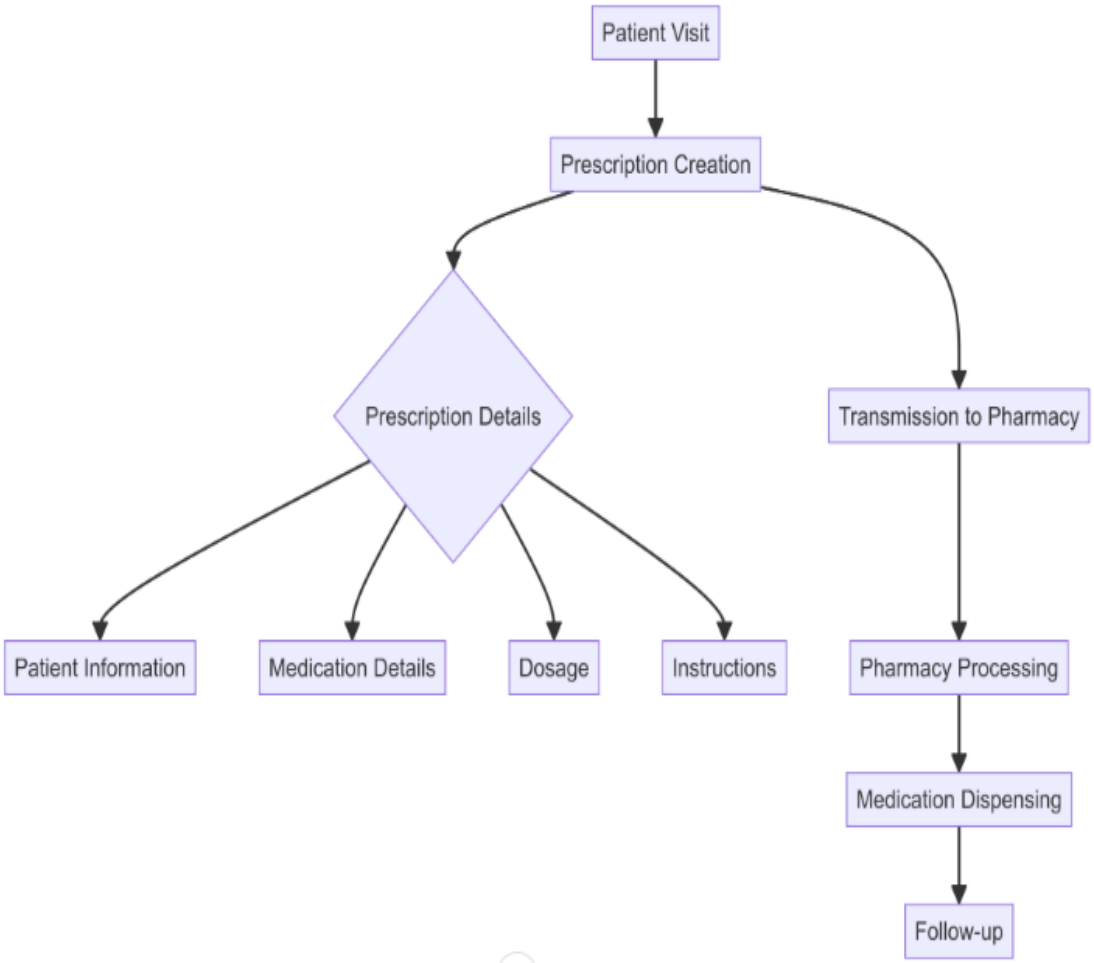

Figure 5-6: ePrescription process when a patient visits the facility (The researchers)

The figure above changes once decision support is incorporated, as depicted in Figure 5-7.

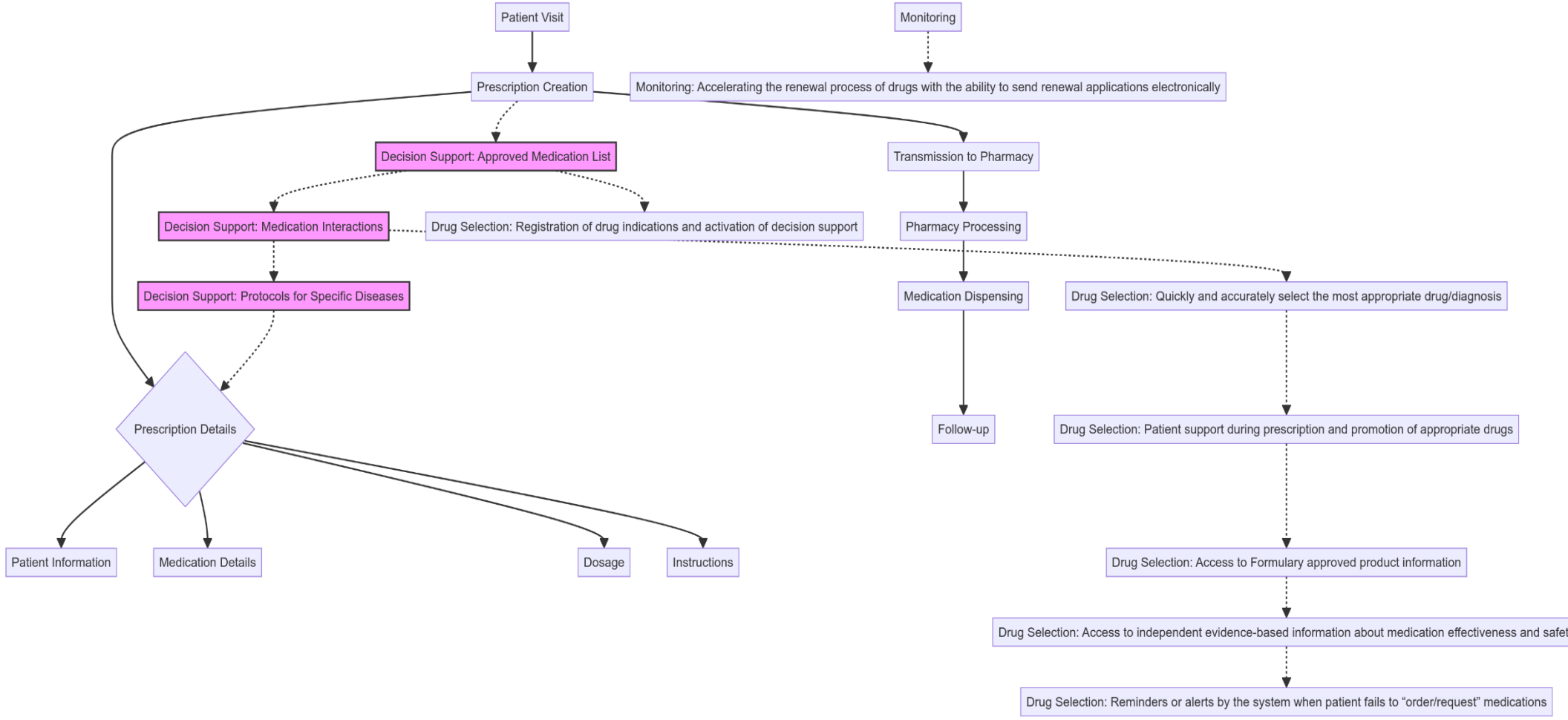

Figure 5-7: ePrescription with decision support incorporated (The researchers)

These system requirements are explained by starting with the patient who visits the facility and all the steps that follow:

- Patient Visit: The process starts with a patient visiting a healthcare provider.
- Prescription Creation: The healthcare provider creates an electronic prescription.
- Prescription Details: Key details include patient information, medication details, dosage, and instructions:
    - Decision Support: Approved Medication List,
    - Decision Support: Medication Interactions, and
    - Decision Support*:* Protocols for Specific Diseases.
- Transmission: The ePrescription is transmitted to the pharmacy.
- Pharmacy Processing: The pharmacy receives and processes the prescription.
- Medication Dispensing: The medication is dispensed to the patient.
- Follow-up: Follow-up actions such as patient education and monitoring are carried out.

5.8.1 Decision Support Elements

The following elements are added to the first Figure 5-8 when decision support is added. These are described and explained below and include:

- Decision Support: Approved Medication List: The system provides a list of approved medications.
- Decision Support: Medication Interactions: The system checks for any potential medication interactions.
- Decision Support: Protocols for Specific Diseases: The system provides protocols for specific diseases to guide the provider.
- Drug Selection: Registration of drug indications and activation of decision support: Ensures appropriate drug indications and support.
- Drug Selection: Quickly and accurately select the most appropriate drug/diagnosis**:** Facilitates the selection of the best medication.
- Drug Selection: Patient support during prescription and promotion of appropriate drugs: Provides support to ensure appropriate drug use.
- Drug Selection: Access to Formulary approved product information**:** Gives access to approved product details.
- Drug Selection: Access to independent, evidence-based information about medication effectiveness and safety: Offers evidence-based information.

- Drug Selection: Reminders or alerts by the system when a patient fails to “order/request” medications: Alerts for missed medication orders.
- Monitoring: Accelerating the renewal process of drugs with the ability to send renewal applications electronically: Speeds up the drug renewal process.

5.8.2 Patient Data Management

Patient data management is involved when:

- Importing and exporting demographic and clinical data.
- Manual entry of patient identification when importing is not possible.
- Merging duplicate records for the same patient.
- Searching for individual users by partial name and demographic data.
- Recording and displaying names and reasons for complementary medicine use.
- Recording and displaying a list of illicit/street drugs used by the patient.
- One can change or discontinue a current medication with proper documentation.
- Recording and displaying clinical information, including past medical history, physical examination, and laboratory results.
- Linking and de-linking records for users within the same family.
- Recording and displaying the patient’s pregnancy status or breastfeeding status.
- Recording and displaying the patient’s lifestyle status. (e.g. athletes should not use certain drugs).
- Recording and updating allergies and drug intolerances.
- Recording and displaying preventive and non-pharmacological management measures.
- Creating a clinical management plan for a patient in a standard and configurable format.

5.8.3 Drug Selection

For drug selection, the following needs to be considered:

- Providing information on drug formulations.
- Registration of drug indications and activation of decision support.
- Quickly and accurately select the most appropriate drug/diagnosis.
- Patient support is provided during prescription and the promotion of appropriate drugs.
- Display recommended therapeutic options for the selected diagnosis.

- Access to *Formulary* approved product information.
- Access to independent, evidence-based information about medication effectiveness and safety.
- Providing information on the availability of cheaper and medically appropriate alternatives.
- Proposing automatic supply of alternative drugs.
- Displaying a list of available strengths and forms for the selected medication.
- Providing a list of predefined dosage regimens suitable for the selected medication.
- Providing information on adult doses and children's doses.
- Access to dose calculators based on weight or age.
- Presentation options for medication selection to avoid errors.
- Select a medication by drug class.
- System reminders when drugs are ignored.
- Ability to write user feedback when prescribing medications.
- Diagnosis-based selection and diagnostics.

5.8.4 Security, Privacy, and Administration

When addressing security, privacy and administration, the following needs consideration:

- Compliance with national privacy regulations.
- Authentication systems for each user.
- Secure support of clinical data.
- Secure transfer of sensitive data.
- Reliable mechanisms for regular updates from the vendor.
- Control access privileges for individual users or groups of users.
- Record and track the provision of data to third parties and receive informed consent.
- 24-hour user access to IT support in case of failure.
- High level of security of anti-theft systems.

5.8.5 Transparency and Accountability

When focussing on transparency and accountability, consider the following:

- Access to information about techniques used to produce decision support tools.
- The user can access information regarding the knowledge sources used for decision support.
- Disclosure of conflict of interest.
- Show pharmaceutical company advertisements.
- Commercial factors should not influence product selections throughout the medicine-choosing process.

5.8.6 Interoperability and Communication

When focussing on interoperability and communication, consider the following as value chain system requirements:

- Interface with other software applications for managing patient data.
- Support the use of nationally agreed clinical terminologies and coding systems.
- Encrypt all messages transmitted between service providers.
- Import and export various file formats associated with a patient record.
- Enabling the prescriber to create and customise templates for letters, referrals, and other documents.
- Enabling the prescriber to analyse and reconcile a list of suggested drugs from another source with the patient's existing prescription list.

5.8.7 Monitoring, Report, Reminder, and Renewals, Feedback at the Prescriber Level

For monitoring, reporting, reminders, renewals and feedback at the prescriber level, consider the following:

- Flagging possible under- or overuse of medications by a patient.
- Reminding the prescriber when a prescription is due or overdue.
- Reminding the prescriber of the need for routine or recommended tests associated with certain medications and conditions.
- Reminding the prescriber when new test results are available for a patient.
- Tracking clinical orders and reminding the prescriber when a selected test or investigation was ordered in the recent past.

- Reminding the prescriber when results are abnormal or require action.
- Reminding the prescriber when users are due or overdue for testing, including screening.
- Accelerating the renewal process of drugs with the ability to send renewal applications electronically.
- Displaying cumulative laboratory test result reports, facilitates trend analysis and highlights out-of-range values.
- Providing a facility to monitor results and clinical outcomes related to specific medications.
- Generating predefined reports enables clinicians to monitor clinical care and audit individual or practice performance.
- Generating reports based on user-defined 'query sets' to monitor clinical care and audit individual or practice performance.
- Generating reports on data for individual prescribers or for all the prescribers in the practice.

5.8.8 Interaction Diagram

This interaction diagram clearly visualises the ePrescription process, highlighting the essential steps and interactions involved.

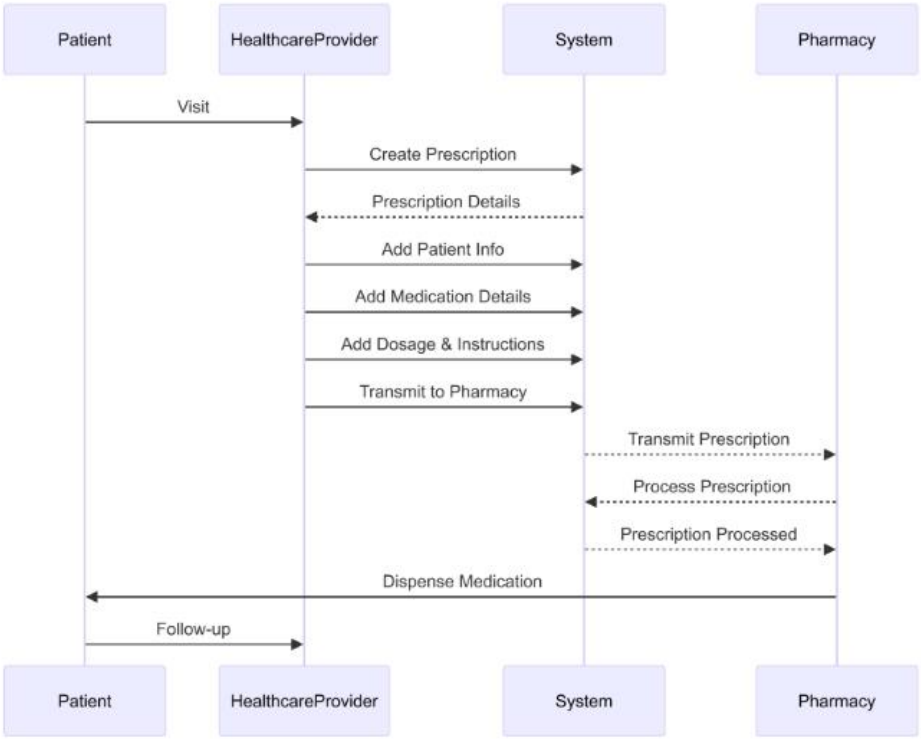

Figure 5-8: Interaction Diagram (The researchers)

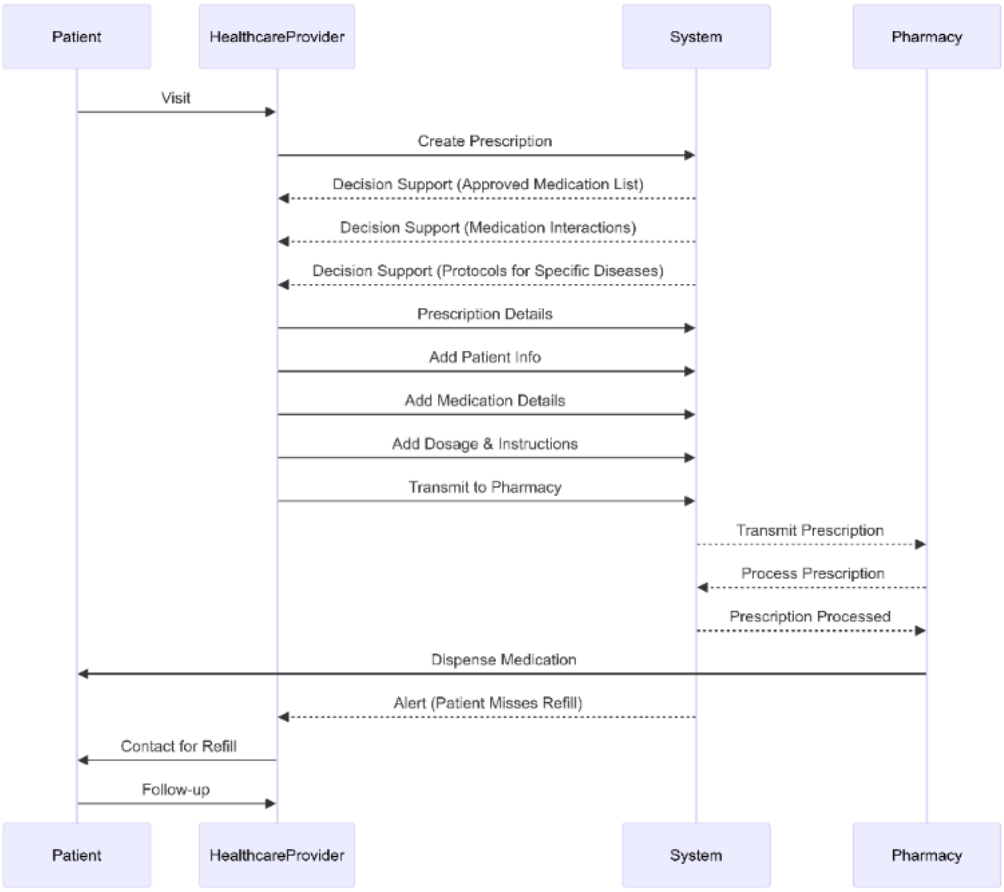

Figure 5-9: Incorporating Decision Support (The researchers)

This interaction diagram illustrates the process flow of electronic prescriptions, highlighting the key interactions between the patient, healthcare provider, system, and pharmacy.

5.8.8.1 Step-by-Step Breakdown

- Patient Visit: The process begins with the patient visiting the healthcare provider for a consultation or treatment.
- Prescription Creation: The healthcare provider creates an ePrescription using the system.
    - Decision Support: Approved Medication List: The system provides a list of approved medications.
    - Decision Support: Medication Interactions: The system checks for potential medication interactions.
    - Decision Support: Protocols for Specific Diseases: The system provides protocols for specific diseases.
- Prescription Details: The system generates the prescription details, which include:

- Patient Information,
- Medication Details,
- Dosage, and
- Instructions.

Adding Information:

- Patient Info: The healthcare provider inputs the patient's demographic and clinical data, including any complementary medicine use, illicit drug use, allergies, drug intolerances, and preventive measures.
- Medication Details: Details about the prescribed medication, such as formulation, dosage regimens, and therapeutic options, are added.
- Dosage & Instructions: The healthcare provider specifies the dosage and usage instructions.
- Transmission to Pharmacy: Once all the necessary details are added, the healthcare provider transmits the ePrescription to the pharmacy through the system.
- Pharmacy Processing: The pharmacy receives and processes the prescription. This includes verifying the prescription details and ensuring the medication is in stock.
- Medication Dispensing: After processing, the pharmacy dispenses the medication to the patient.

Follow-up: The patient may have follow-up visits with the healthcare provider to monitor and address any questions or concerns about the medication.

5.8.8.2 Key Features and Functionalities

- Patient Data Management: The system supports importing/exporting patient data, manual entry of patient identification, merging duplicate records, and searching for users by partial name or demographic data. It also records and displays clinical information, such as pregnancy, breastfeeding, elite athletes, and more.
- Drug Selection: The system provides comprehensive drug information, registration of indications, support for selecting the appropriate drug, access to evidence-based information, and dosage calculators. It also suggests cheaper alternatives and predefined dosage regimens. The decision support elements include providing information on drug interactions, approved medication lists, protocols for specific diseases, and alerts for missed refills.
- Security, Privacy, and Administration: The system ensures compliance with privacy regulations, user authentication, secure data transfer, and controlled access privileges. It also supports regular updates and provides 24-hour IT support.

- Transparency and Accountability: Users can access information about decision support tools, knowledge sources, and potential conflicts of interest. The system also maintains transparency when displaying pharmaceutical advertisements.
- Interoperability and Communication: The system interfaces with other software applications, supports clinical terminologies and coding systems, encrypts messages, and allows importing/exporting various file formats. It also enables creating and sending reports and customising templates for documents.
- Monitoring, Reporting, Reminders, and Renewals: The system helps monitor medication use, remind prescribers of due/overdue prescriptions and tests, tracks clinical orders, and facilitates the renewal process. It generates reports for trend analysis and clinical outcomes monitoring. The decision support elements include reminders for when patients miss refills and recommendations based on monitoring clinical outcomes.

5.9 Country Perspectives

ePrescribing systems are designed according to each country's specific needs and internal standards. Numerous studies have been conducted worldwide to investigate the benefits, challenges, and reasons for such systems' failure and lack of acceptance (Bouraghi et al., 2024).

5.9.1 International

ePrescribing systems in countries like Denmark, the United States, Finland, Sweden, and the United Kingdom are commonly tested and implemented at state, local, or regional levels. These systems cover the entire or a significant portion of the prescribing process (Bouraghi et al., 2024).

The adoption and implementation of ePrescription systems varies across countries due to differences in healthcare systems, regulatory environments, and technological maturity (Farghali et al., 2021). In developed countries like the US, the UK, and Australia, ePrescription has seen significant adoption and integration with EHRs and pharmacy management systems (Dastani & Atarodi, 2022; Ahmadi et al., 2017). These countries exhibit distinct starting points, implementation procedures, and technical strategies, and they have reached significant maturity and yielded substantial advantages for their health systems (Bouraghi et al., 2024).

However, in many developing countries, the ePrescription ecosystem is still nascent, with manual, paper-based prescription processes being the norm (Samadbeik et al., 2017). Developing countries still encounter significant challenges to widespread acceptance and goal achievement (Chang, 2020; Cresswell, 2015; Fischer, 2020). Moreover, ePrescribing systems and models vary across different countries and within the same country (Samadbeik et al., 2023).

The experiences of developed countries provide valuable lessons for developing nations looking to implement ePrescription systems:

- Establishing a comprehensive regulatory framework to govern ePrescription systems, including standards, privacy, and security requirements (Aldughayfiq & Sampalli, 2021; Ahmadi et al., 2017; Kauppinen et al., 2017a).
- Building robust and interoperable information systems to enable end-to-end ePrescriptionworkflows, integrating EHRs and pharmacy management systems (Aldughayfiq & Sampalli, 2021; Ahmadi et al., 2017).
- Incentivising healthcare providers to adopt ePrescription through policy measures and financial support (Hahn & Lovett, 2014).
- Promoting ePrescription education and awareness among prescribers, pharmacists, and patients to drive uptake and utilisation (Kauppinen et al., 2017b; Samadbeik et al., 2023)
- Monitoring and continuously improving ePrescription systems based on user feedback and performance metrics.(Ahmadi et al., 2017; Kauppinen et al., 2017).
- Developing countries can leverage the successes and learn from the challenges faced by early adopters of ePrescription systems to accelerate the deployment of tailored solutions that address their local healthcare needs and contexts.(Aldughayfiq & Sampalli, 2021).

5.9.2 Developed countries and their ePrescription systems

Below is a comparative analysis of ePrescription systems in eight countries: Canada, the United States of America (USA), the United Kingdom, Australia, Spain, Japan, Sweden, Denmark, Ireland, Norway, Netherlands, New Zealand and Estonia. The following tables present a comprehensive view of the ePrescription systems implemented in various countries, detailing their system architecture, digital security, privacy protocols, patient identity verification methods, advantages, disadvantages, and secure communication methods. This analysis can offer insights into the different approaches taken by each country.

Table 5-3: Combined EPrescribing Systems Analysis

Country	Summative Narrative	System Architecture	Digital Security	Privacy Protocols	Patient Identity Verification Methods	Advantages of system	Disadvantages of system
Canada (Ministry of Health, Canada, 2018)	Canada's ePrescription system, PrescribeIT, is centralised with secure communication, effective Drug Information System (DIS), integration with Electronic Medical Records (EMR), ePrescription status and alerts, and access control. It offers nationwide integration and enhanced security but faces partial implementation in provinces and reliance on existing health systems.	Centralised (PrescribeIT)	Secure communication, multifactor authentication, encrypted transmission, access control	Integration with EMR, ePrescription status and alerts, patient consent required	Access control, multifactor authentication	Nationwide integration, enhanced security, comprehensive drug information	Partial implementation in provinces, reliance on existing health systems
United States (SureScripts, 2019)	The United States uses a decentralised system, SureScripts, which includes medication history, formulary benefits, electronic prior authorisation, and peer-to-peer communication. It provides real-time medication history access and benefit optimisation but suffers from fragmented data storage and reliance on subscriptions for data sharing.	Decentralised (SureScripts)	Managed by network services, real-time updates	Peer-to-peer communication, medication history access	Network service managed authentication	Real-time medication history access, benefit optimisation	Fragmented data storage, reliance on subscriptions for data sharing

Country	Summative Narrative	System Architecture	Digital Security	Privacy Protocols	Patient Identity Verification Methods	Advantages of system	Disadvantages of system
United Kingdom (NHS England, 2023, February 6)	The United Kingdom's EPrescriptionService (EPS) is centralised, integrating with the NHS Spine system and using smartcard authentication. It processes prescriptions efficiently and ensures secure patient information exchange, though it is limited to selected controlled drugs and requires patient consent.	Centralised (EPrescriptionService - EPS)	Smartcard authentication, NHS Spine system integration	Patient consent required, secure patient information exchange	Smartcard authentication	High prescription processing efficiency, integrated with NHS systems	Limited to selected controlled drugs, need for patient consent
Australia (Australian Digital Health Agency, 2020)	Australia employs a decentralised system with eRx Script Exchange and MediSecure, offering secure prescription transfer, integration with My Health Record, encryption, and real-time monitoring. It is secure and integrated with the national health record but requires patient consent for data upload and faces partial system integration.	Decentralised (eRx Script Exchange and MediSecure)	Secure encryption, real-time monitoring, and compliance with the Privacy Act 1988	Patient consent for data upload, integration with My Health Record	Patient consent, My Health Record integration	Secure, integrated with national health record, real-time monitoring	Requires patient consent for data upload, partial system integration
Spain (Ministry of Health, Spain, 2019)	Spain's national ePrescription system is centralised, featuring medication coding, integration with Electronic Health Records (EHR), and eDispensing services. It ensures nationwide prescription access and	Centralised	SNOMED-CT coding, secure national databases	EHR integration, medication coding	Secure national databases, SNOMED-CT coding	Nationwide access to prescriptions, comprehensive drug interaction checks	High reliance on national databases, potential for complex implementation

Country	Summative Narrative	System Architecture	Digital Security	Privacy Protocols	Patient Identity Verification Methods	Advantages of system	Disadvantages of system
	comprehensive drug interaction checks but relies heavily on national databases and has a complex implementation.						
Japan (Ministry of Health, Japan, 2020)	Japan's proposed ePrescription system is decentralised with centralised components, using QR code access, PHR integration, and cloud-based prescription retrieval. It is modern and patient-controlled but has complex implementation, higher costs, and partial current implementation.	Decentralised with centralised components (proposed system)	QR code technology, centralised cloud system	Patient-controlled data access, PHR integration	QR code access, PHR integration	Modern proposed system, patient-controlled data access	Complex implementation, higher costs, partial current implementation
Sweden (Swedish eHealth Agency, 2018)	Sweden's national ePrescription repository is centralised, utilising smartcard technology and a national prescription database with XML message formats. It was an early adopter with a comprehensive national database and secure data transfer but requires smartcard infrastructure and faces centralised data vulnerabilities.	Centralised (national ePrescription repository)	Smartcard technology, secure national database, XML message format	Secure patient data transfer, comprehensive national database	Smartcard technology	Early adoption, comprehensive national database, secure data transfer	Requires smartcard infrastructure, centralised data vulnerability
Denmark (Danish Medicines Agency, 2019)	Denmark's system managed by the Danish Medicines Agency is centralised, with nationwide EHR	Centralised (managed by Danish Medicines Agency)	Managed by Danish Medicines Agency, secure data access	Nationwide EHR integration, comprehensive medication records	Secure data access managed by Danish	Robust national infrastructure, high population coverage	Centralised system vulnerabilities, high initial

Country	Summative Narrative	System Architecture	Digital Security	Privacy Protocols	Patient Identity Verification Methods	Advantages of system	Disadvantages of system
	integration and comprehensive medication records. It boasts a robust national infrastructure and high population coverage but is vulnerable to centralised system attacks and has high initial implementation costs.				Medicines Agency		implementation costs
New Zealand (Health New Zealand, 2024, April 17)	The ePrescription Service (NZePS) was part of the national eMedicines programme.	1D barcode system for prescription retrieval.	Secure transaction broker and digital signatures.	Compliance with national privacy laws and data protection standards.	National health identifier and secure authentication.	Successful community trials and national rollout; streamlined prescription retrieval.	Initial community trials required; full national rollout took time.
Ireland (eHealth Ireland, 2023, December 20)	Ireland is working to develop standards for ePrescribing, informed by a review of international initiatives.	Phased, standards-based implementation with pilot projects.	Secure transmission and digital signatures.	National privacy laws and data protection standards.	National health identifier and secure login.	Pilot projects mirroring current business processes; phased approach for adaptation.	Initial phases are still in progress; full implementation is pending.
Netherlands (Aldughayfiq & Sampalli, 2021, February 1)	All GPs use an electronic medical record management system that includes ePrescribing, though there is no national system for the electronic exchange of prescription information.	Electronic medical record management system with ePrescribing module.	Secure healthcare mail system using EDIFACT messages.	Compliance with national privacy laws and data protection standards.	National identification number and secure access.	High usage of electronic medical records; regional networks for prescription exchange.	Lack of a national system for electronic exchange; reliance on regional networks.
Estonia (Tervisekassa, 2024, August 13)	Estonia is one of the most digitally advanced nations. All prescriptions are managed electronically, and the ePrescribing	Fully digital ePrescribing service integrated with the national health system.	Secure digital signatures and encrypted data transfer.	Strict national privacy regulations and data protection laws.	National ID card and secure login.	High adoption and success rates; patients can request refills via	Initial capacity issues with the 'big bang' approach;

Country	Summative Narrative	System Architecture	Digital Security	Privacy Protocols	Patient Identity Verification Methods	Advantages of system	Disadvantages of system
	service is highly successful.					various digital methods.	required accurate capacity analysis.
Norway (Norsk helsenett, 2021, March 19)	ePrescribing began as a pilot project in 2004 and was fully implemented by 2013 following a comprehensive eHealth strategy.	A comprehensive system covering prescription generation, transfer, and reimbursement.	Secure transfer of prescriptions and digital signatures.	National regulations ensure data privacy and protection.	National health care and secure authentication.	Comprehensive coverage of ePrescribing and reimbursement; extensive stakeholder engagement.	The initial pilot faced unexpected challenges; and required infrastructure revisions.

5.9.3 Various ePrescription systems from selected countries

The publicly available data collected from the countries included the following (Aldughayfiq & Sampalli, 2021, February 1):

- The e-Prescription system architecture components: Such components are the architecture type (i.e., centralised or decentralised system), prescription database, medication database, medication history database, clinical decision support (CDS) features, issuing a paper prescription, electronic prescribing types, medical records, and e-Prescription for controlled medicine.
- The system security and privacy protocols (use of Health Level Seven International [HL7] protocol, patient consent, and patient's identity verification) and the system components identifiers (Pharmacy ID, Prescriber ID, Medication ID, Prescription ID, and Patient ID).
- The ePrescription system process (the ePrescription information availability to the involved parties, the availability of Drug-Drug Interactions [DDI] information based on the patient health record, storing the ePrescription information for future uses, and the electronic transfer of the prescription to a pharmacy).

The ePrescription systems from Canada, USA, UK, Spain, Australia, Japan and Sweden are provided.

5.9.3.1 Canada's ePrescription System

Canada's government-funded ePrescription system aims to be used nationwide in all provinces (Canada Health Infoway, 2019). Infoway conducted a workshop in 2016 with several prescribers and pharmacists to explore issues in the paper prescription system (Canada Health Infoway, 2018). The primary purpose of this system is to act as a medium to transfer and exchange prescription information between a prescriber and a pharmacist. The following are the main requirements that resulted from the study for PrescribeIT (Aldughayfiq & Sampalli, 2021, February 1):

- Secure communication between the pharmacy and the prescriber.
- Effective Drug Information System (DIS) to detect drug interactions for both the pharmacy and prescriber.
- Integration with an Electronic Medical Record (EMR) management system.
- ePrescription status and alert to the prescriber.
- Security and privacy in accessing patient information.

PrescribeIT defines ePrescription as the process of transmitting a prescription between a prescriber and a pharmacy with the condition of not affecting the clinical workflow (Canada Health Infoway, 2018). The prescription information is encrypted from a prescriber to a patient's pharmacy, which

provides access control. The system intends not to replace the current pharmacy management system or the prescriber's office. Instead, the system helps monitor the prescription by storing a patient's prescription information in the system.

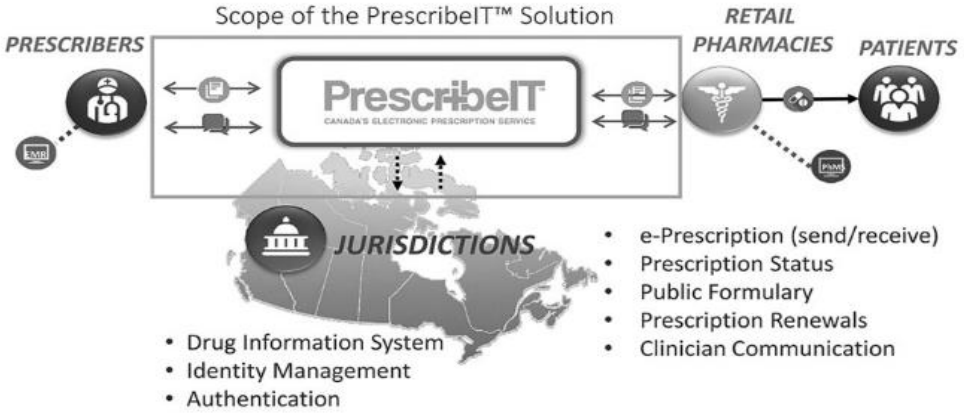

Figure 5-10: Explaining the PrescribeIT system (PrescribeIT, 2018)

In Figure 5-11 the complete architecture and features that will be deployed in the future, is explained.

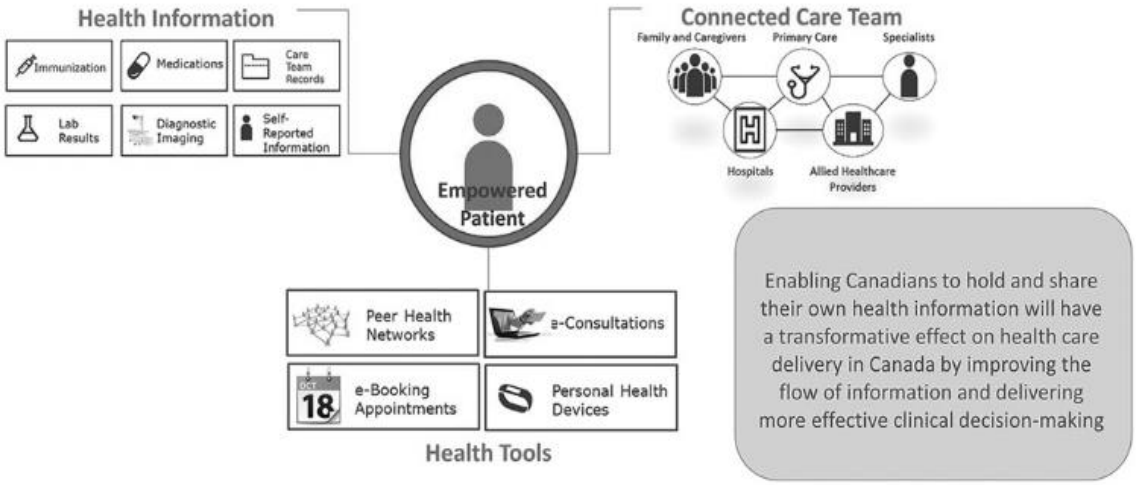

Figure 5-11: PrescribeIT architecture (Canada Health Infoway, 2018)

The user must use password authentication to access the assigned levels in the system. Moreover, for security, all transactions in the system are logged and audited (Canada Health Infoway, 2019; PrescribeIT, 2018).

5.9.3.2 USA SureScript System

Superscript is the United States e-prescription system that provides an ePrescription network where the stakeholders in the system can communicate and exchange data ((Aldughayfiq & Sampalli, 2021, February 1). The parties in the network can communicate with each other using peer-to-peer communication, and it provides the prescriber with the patient's medication history and formulary and benefits information from participating insurers and pharmacy benefit managers (PBMs) (SureScripts, 2019).

SureScripts manages the security and privacy of patient data based on the service provided. Benefit optimisation is a service that ensures that the patient's drug information is updated and accessible in real-time during patient visits. Another service SureScripts provides is the medication history and clinical history, where the caregivers will request the previous care location the patient has attended (Superscript, 2019).

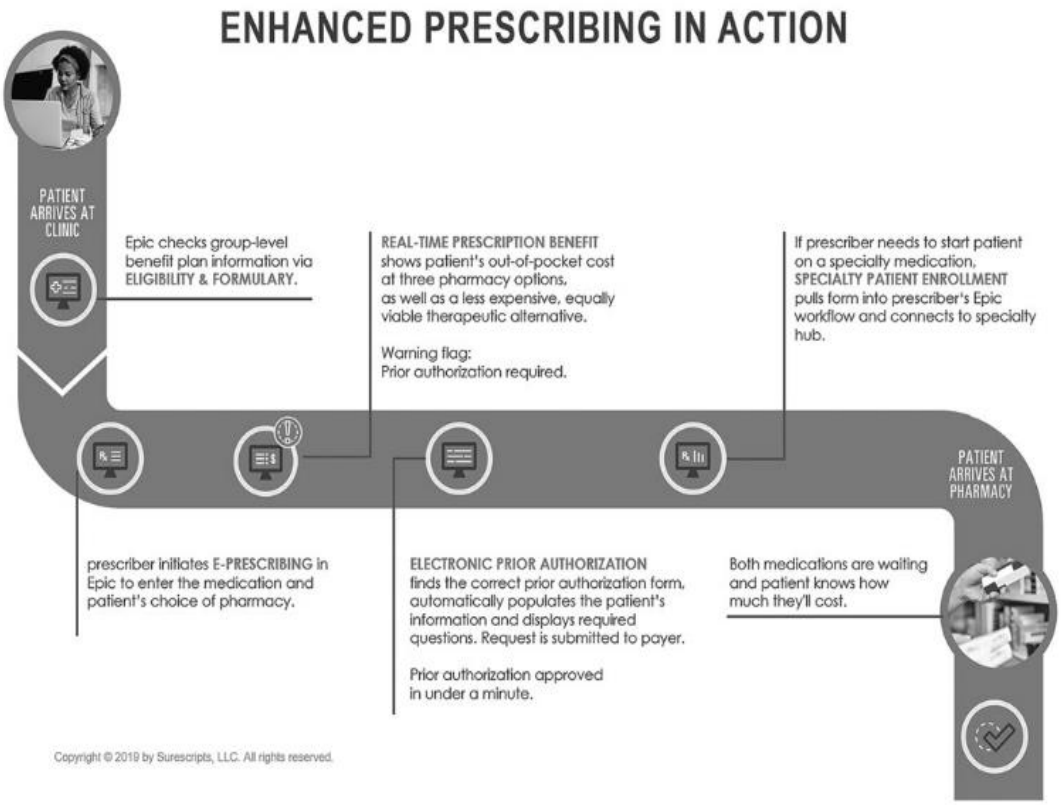

Figure 5-12: Key features of the SureScripts system (2019)

5.9.3.3 The ePrescription System of the United Kingdom

The NHS England (2019) identifies that the most common users of the EPrescriptionService (EPS) are patients who get repeat prescriptions and patients who use one pharmacy to dispense all their

prescriptions. The EPS is sent through the NHS Spine system, allowing the secure exchange of patient's health and care information between care provider organisations when needed (NationalHealth Service Digital, 2019e; PSNC, 2019). Patient consent is needed to participate in the EPS. Figure 5-13 shows the EPSoverview system (National Health Service Digital, 2019c). The system uses smartcard authentication for the healthcare provider to access NHS Spine services, such as EPS and the patient's Summary Care Record (National Health ServiceDigital, 2019d, 2019e; PSNC, 2019). The service is used to identify the health care provider and their access levels for patient information (National Health Service Digital, 2019d; PSNC,2018). The system also allows the patient to choose the preferred pharmacy through the prescriber. This step is called nomination; a patient's consent is required to participate in the EPS service. Moreover, the patient can request a paper prescription from the prescriber at any time (NHS England, 2019). Furthermore, The system uses unique identifiers for the prescription form, and when the prescriber issues a prescription, the system creates three identifiers: (1) the prescription form,(2) the short prescription form ID, and (3) the prescription line item Unique User Identifier (UUID).

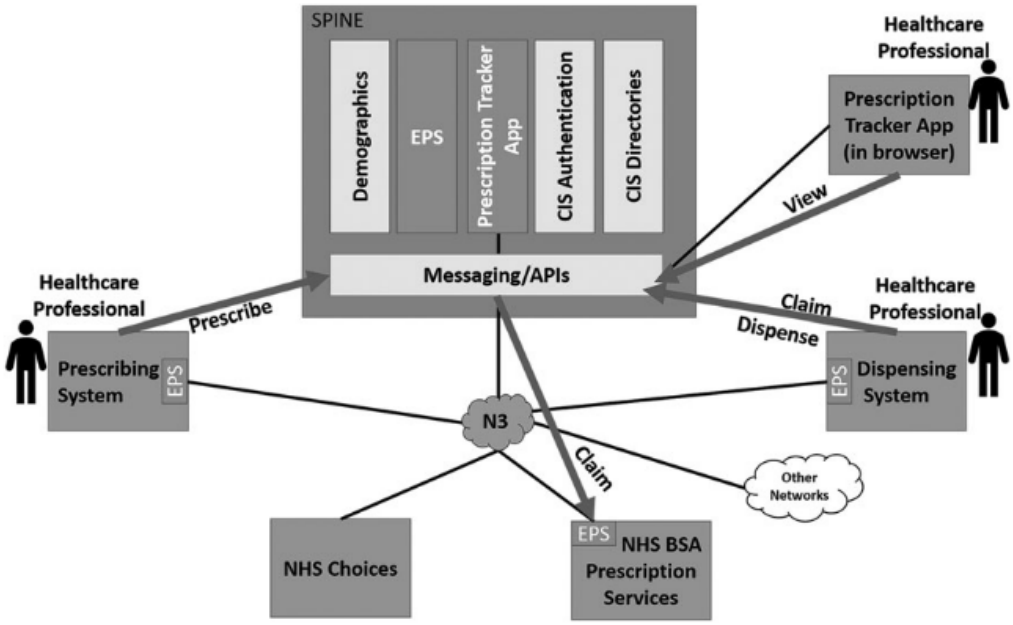

Figure 5-13: UK e-Prescription service architecture (adapted from NHS England, 2019)

5.9.3.4 Spain's ePrescription System

In Spain, the primary goal of the e-prescription system is to ensure the patient's safety and improve the patient's treatment care (Lizano-Diez et al., 2014). According to the health authorities in Spain, the system must include a list of possible medications that are allowed to be prescribed. The medication list has a coding system for all the information about every medication approved on the list (Ministry of Health, Spain, 2019). The list is likely to help detect drug interactions, and the

system is connected to the patient's EHR to help identify any additional interactions or allergies to the prescribed medicine. In addition, the prescription will be shared with any other prescriber treating the patient.

Furthermore, active prescriptions will be accessible to all pharmacies in the country. The patients can pick up their medications at any pharmacy in the country. The system uses the Systematised Nomenclature of Medicine-Clinical Terms (SNOMED-CT) to code all the information (Aldughayfiq & Sampalli, 2021, February 1).

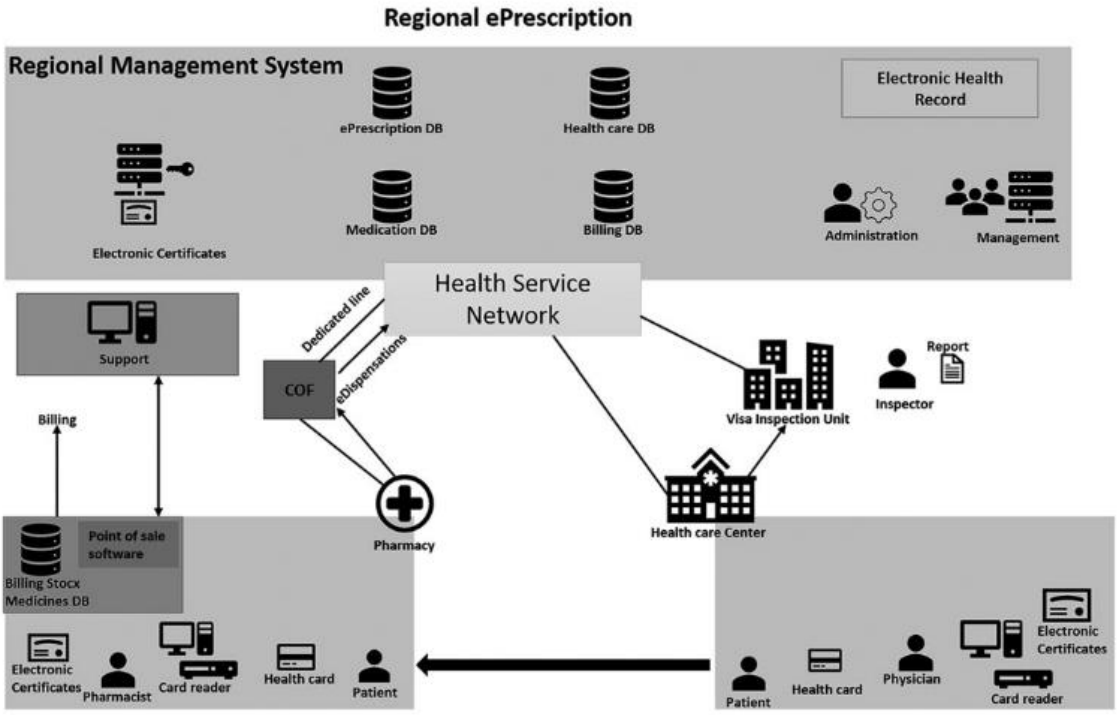

Figure 5-14: Spain's ePrescription system (Ministry of Health, Spain, 2019)

5.9.3.5 Japan's ePrescription System

Japan's ePrescription system issues an access code to the patient after the prescriber submits prescription data. The patient can get the access code on paper or in electronic form and send it to their Personal Health Record (PHR) application (Aldughayfiq & Sampalli, 2021, February 1). The system generates the access code using QR code technology. After the patient goes to the pharmacy to pick up the medication, the pharmacy scans the QR code to get the prescription information from the prescription system in the cloud (Ministry of Health, Japan, 2020). The pharmacy then starts the dispensing process. Finally, the pharmacy updates the prescription system with the prescription dispensing data. Furthermore, the patient's PHR application will be updated with the dispensing information to keep it in the electronic medication notebook (Ministry of Health, Japan, 2020). The system connects to the EMR system with the pharmacies' databases using the HL7

standard Fast Healthcare Interoperability Resources (FHIR) (HL7, 2019; HL7-FHIR-Release-4, 2019 (Aldughayfiq & Sampalli, 2021, February 1).

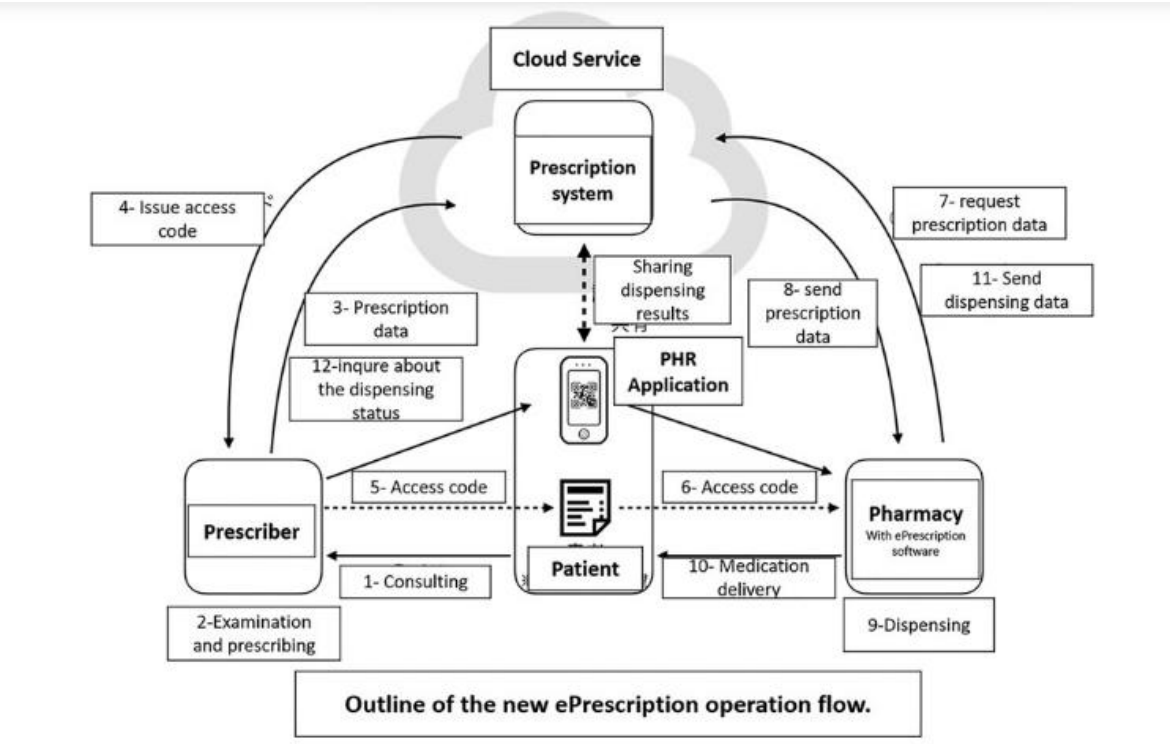

Figure 5-15: Japan's ePrescription System(Ministry of Health, Japan, 2020)

5.9.3.6 Sweden's ePrescription System

Sweden already implemented the patient smart cards in 1980 to re-place paper prescriptions. The patient's smart cards contain information about recently prescribed medications (Aldughayfiq & Sampalli, 2021, February 1). After the prescriber writes the information on the card, the patient takes it to a pharmacy, where the pharmacist can access the information on the card with the help of the supporting system (Hassel, 2019). Furthermore, the patient can take the card with their recent medication history to any other prescriber. In the prescription writing process, the prescriber uses the support system to access all the information about medication from an additional database generated from three sources (Swedish eHealth agency, 2018): The product database created and updated by the pharmacies—the medication information about each medication, the recommended dose, and the side effects. The drug book contains information about diseases and which medications are used to treat certain diseases (Hassel, 2019). For access control, the smart card developers made the patient's information only accessible by using the keys stored in the authorised caregiver card keys (Hammar et al., 2010). In the late 1990s, the use of EHR systems in outpatient clinics increased by 90%, which led to the rise in the electronic transfer of prescriptions in recent decades. Sweden and Denmark were the world leaders in adopting ePrescriptiontransfer using the Electronic Data Interchange For Administration Commerce and

Transport(EDIFACT) message format (Aldughayfiq & Sampalli, 2021, February 1). The Swedish ePrescription system is provided below.

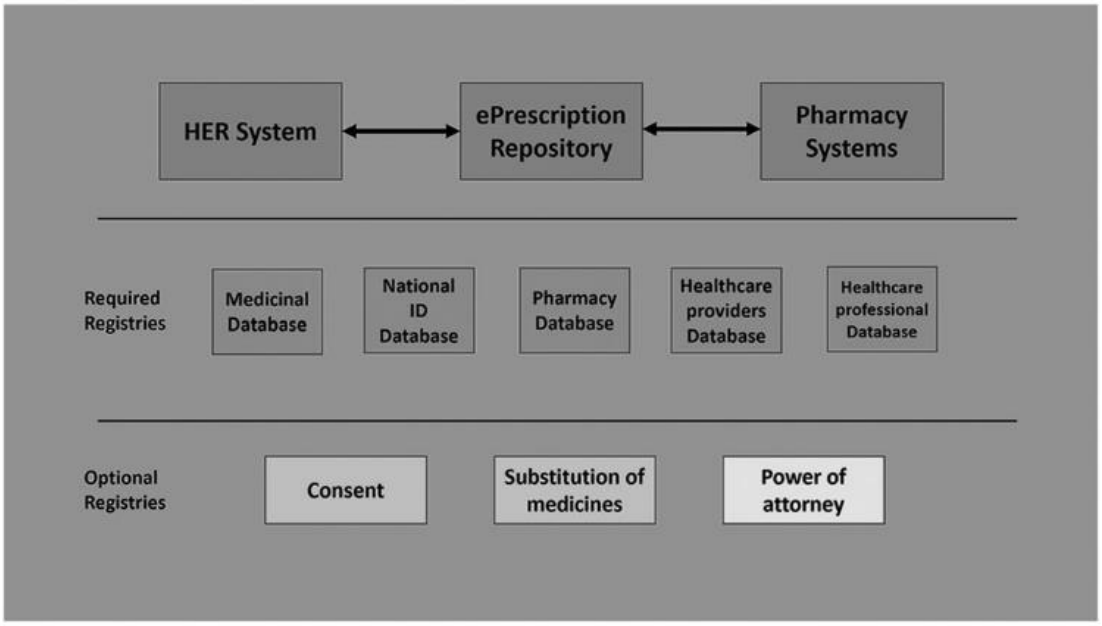

Figure 5-16: Sweden's ePrescription System (Hassel, 2019)

5.9.3.7 Lessons Learned from Country Implementations

The following lessons learned by the various countries are provided in the table below from the literature reviews, thematic analysis and document analysis.

Table 5-4 Country Lessons Learned and Design Heuristics According to Country Implementations

Country	Lessons Learned	Design Heuristics according to country implementation
Canada (Sullivan-Taylor et al., 2022, January 1)	Integration with existing health systems and secure communication protocols is crucial.	Ensure nationwide integration and enhanced security measures.
United States (SureScripts, 2019)	A decentralised approach offers real-time medication history access but suffers from fragmented data storage.	Optimise benefit access and minimise data fragmentation through improved interoperability.
United Kingdom (NHS England, 2023, May 15)	The efficiency of centralised systems and the importance of patient consent are essential.	Utilise smartcard authentication and integrate with national health systems while ensuring patient privacy.
Australia (Aldughayfiq & Sampalli, 2021)	Secure prescription transfer and real-time monitoring are critical.	Implement secure encryption and require patient consent for data uploads.
Spain (Lizano-Diez et al., 2014)	Comprehensive drug interaction checks through centralised systems.	Integrate medication databases with national health records for enhanced patient safety.

Country	Lessons Learned	Design Heuristics according to country implementation
Japan (Ministry of Health, Japan, 2020)	Emphasise patient-controlled data access with implementation challenges.	Use QR code access and cloud-based retrieval for modern, patient-centric systems.
Sweden (Swedish eHealth Agency, 2018)	Secure data transfer and national databases are valuable for early adopters.	Ensure secure data transfer and infrastructure for smartcard technology.
Denmark (Danish Medicines Agency, 2019)	Stress the robustness of centralised infrastructures and their vulnerabilities.	Maintain high population coverage and robust security protocols.
Norway (Quinn & McKelvey, 2019)	A single national authority must work closely with stakeholders to establish infrastructure and define standards. Effective engagement with stakeholders, especially vendors, to ensure system compatibility. There is a need for a flexible system to adapt to practical use and regulatory changes.	Establish a central authority to coordinate efforts and ensure compliance. Engage with stakeholders early and often to gather input and foster collaboration. Build flexibility into the system to accommodate changes and improvements.
Estonia (Lauis et al., 2017; Palma, 2022; Jõgi, 2023; Jõgi, 2024)	The necessity of accurate capacity analysis before a 'big bang' national rollout. Strong stakeholder engagement to address resistance and ensure buy-in. Public trust and a solid legislative framework are crucial for successful implementation.	Conduct thorough capacity analysis and pilot testing before full-scale implementation. Engage with stakeholders continuously to gather feedback and address concerns. Ensure a robust legislative framework and build public trust in the system.
Netherlands (Ignat, 2023)	The value of having all GPs use an electronic medical record management system. The challenge of lacking a national system for electronic exchange results in relying on regional networks instead.	Encourage the use of standardised electronic medical record systems among all prescribers. Develop a national system for ePrescription exchange to ensure uniformity and efficiency.
Ireland (National ePrescribing Project, 2023, December 20)	The importance of a phased, standards-based implementation with pilot projects. Stakeholder engagement needs to mirror current business processes and gather user feedback.	Implement the system in phases to allow for gradual adaptation and improvement. Conduct pilot projects to test the system and gather feedback from stakeholders before full implementation.
New Zealand	The effectiveness of community trials to ensure system reliability and stakeholder acceptance. Importance of a national rollout following successful trials.	Conduct community trials to validate the system and build stakeholder confidence.

Table 5-4 summarises the lessons learned and aims to present design heuristics from each country's implementation of ePrescription systems, providing insights for improving the design and implementation of such systems globally.

5.9.4 South African Regulatory Framework for ePrescription Implementations

As South Africa embarks on developing the South African Health Information system, ePrescription, as a building block in this system, should consider specific regulatory frameworks for implementation.

5.9.4.1 The Medicines and Related Substances Act 101 of 1965

The Medicines and Related Substances Act 101 of 1965 (RSA, 1965), regulates the use of medicines and related substances in South Africa, ensuring that prescriptions are issued and dispensed safely and effectively.

This Act makes specific provisions for:

- Legibility and Format: Prescriptions must be written in legible print, typewritten, or computer-generated and signed by an authorised prescriber.
- Electronic Transmission: Regulation 33 allows for the electronic transmission of prescriptions, including via fax and verbal communication, provided they are permanently recorded.

The following considerations for the implementation should be considered under this Act (RSA, 1965):

- Verification Process**:** Systems must include mechanisms to ensure that electronic prescriptions are accurately verified and recorded.
- Record-Keeping**:** Healthcare providers must establish protocols to maintain permanent records of electronically transmitted prescriptions to comply with legal requirements.
- Security Measures**:** Adequate security measures must be in place to protect electronic prescriptions from unauthorised access or tampering.

5.9.4.2 Electronic Communications and Transactions Act (ECT Act) of 2002

The ECT Act (2002) facilitates electronic communications and transactions, legally recognising electronic documents and signatures.

Specific Provisions of the ECT Act (2002) include:

- Legal Force: Electronic prescriptions have the same legal force as traditional paper documents if they are a data message and accessible for subsequent reference.
- Electronic Signatures**:** When properly applied, electronic signatures accompanying prescriptions are considered legally valid.

The following should be considered for implementations of ePrescription in South Africa, based on this Act:

- Electronic Signature Validation: Implement systems to validate electronic signatures to ensure legal compliance.
- Accessibility and Storage: Ensure that electronic prescriptions are stored in a manner that preserves their integrity and can be accessed for future reference.
- System Integration: Integrate e-prescription systems with existing electronic health records to maintain continuity and accuracy in patient records.

Key takeaways from the legislation (Scott, 2023, July 30):

- When a prescription has been prepared using an electronic agent and signed using an advanced electronic signature, it meets the legislative requirements of electronic prescribing and constitutes the original script.
- When a script is legally compliant, it does not need to be emailed from the doctor's rooms (for any medicine schedule). There has been confusion about this partly due to the lack of legally compliant electronic prescription systems available locally to date and suggestions made by the Pharmaceutical Society of South Africa (PSSA) regarding Schedule 5 and 6 prescriptions during the COVID-19 national lockdown. The PSSA recommendations were intended to facilitate access to medicines during the lockdown period when fully legally compliant prescribing systems (electronic agents using AES) were not readily available.
- The Advanced Encryption Standard (AES) signed PDF is the valid original script and can be kept for South African Pharmacy Council (SAPC) audits.

Apart from the Acts, it is also important to focus on the SAPC Guidelines and the standards as explained in the HNSF.

5.9.4.3 South African Pharmacy Council (SAPC) Guidelines

The SAPC provides guidelines to ensure the proper use and authentication of e-prescriptions, safeguarding against forgery and errors. Specific Provisions from the SAPC (2008) involve:

- Direct Transmission: Encourages prescriptions to be sent directly from prescribers to pharmacies to avoid issues with authenticity and duplication.
- Verification: Pharmacists must verify the authenticity of electronic prescriptions before dispensing.

The following considerations are crucial to consider for Implementation (SAPC, 2008)**:**

- Direct Communication Channels: Establish secure channels for direct transmission of prescriptions from prescribers to pharmacies.

- Verification Protocols: Develop protocols for pharmacists to verify the authenticity of electronic prescriptions, including checking for any signs of tampering.
- Training: Provide pharmacists with training on the new verification processes and the use of e-prescription systems.

5.9.4.4 National Health Normative Standards Framework for Interoperability in eHealth

The HNSF (2021) framework aims to standardise electronic health information systems across public healthcare facilities, facilitating the integration of e-prescription systems with other health records. The specific provision in the HNSF involves interoperability to ensure that different health information systems can work together seamlessly to provide comprehensive patient care Ntafi et al. (2022).

Considerations for Implementation of an ePrescription system relating to the HNSF (2021) involve**:**

- Standardisation: Ensure that e-prescription systems adhere to national standards for interoperability to facilitate integration with other health systems.
- System Compatibility: Interoperability of existing health information systems with the e-prescription platform.
- Data Security: Implement robust data security measures to protect patient information during transmission and storage.

5.9.4.5 Possible Stumbling Points When Implementing an Eprescription System in South Africa

Based on the lessons learned from country implementations the following possible stumbling points should be considered by the NDoH when implementing an ePrescription system.

Table 5-5: Possible Stumbling Points to Consider When Implementing an Eprescription System

Point	Challenge	Critique
Verification and authentication	Ensuring the authenticity of electronic prescriptions can be complex, especially when prescriptions are sent to patients rather than directly to pharmacies.	This adds an extra burden on pharmacists to verify prescriptions, potentially delaying dispensing and increasing the risk of errors.
Technology infrastructure	Implementing e-prescription systems requires robust technology infrastructure, including secure electronic transmission channels and reliable storage systems.	Many healthcare facilities may lack the necessary infrastructure, especially in rural areas.
Education and training	Both healthcare providers and patients need to be educated about the proper use of e-prescriptions.	Insufficient training can lead to misuse or errors in the ePrescribing process. Continuous education and

Point	Challenge	Critique
		support are essential to ensure effective implementation.
Legal and Regulatory Compliance	Compliance with multiple regulations, including the Medicines Act and the ECT Act, requires significant administrative effort.	Navigating these legal requirements can be cumbersome, and any misstep could result in legal repercussions for healthcare providers and pharmacists.
Security and Privacy	Ensuring the security and privacy of electronic health information is crucial to prevent unauthorised access and data breaches.	Implementing adequate security measures can be costly and technically challenging, particularly for smaller healthcare providers.
Patient Acceptance and Accessibility	Patients must accept and be comfortable with receiving electronic prescriptions.	Ensuring accessibility for all patients, including those who may not be tech-savvy or have limited access to digital devices, is essential for the success of e-prescription systems.

5.9.5 Suggested Functional and Technical Capabilities for an EPrescribing System from International Implementations

The table below outlines the suggested functional and technical capabilities required for an ePrescription system.

Table 5-6: Functional and Technical Capabilities of an Effective ePrescription System (The Researchers)

Capability Type	Capability	Description	Key Features
Functional	User Authentication and Access Control	Ensures only authorised users can access the system.	Multi-factor authentication, role-based access control, secure login/logout
Functional	Prescription Management	Facilitates creation, modification, and transmission of electronic prescriptions.	Prescription creation, modification, secure transmission, refill management
Functional	Patient Management	Manages patient information, including medical history and allergies.	EHR integration, patient history access, allergy alerts
Functional	Drug Information and Interaction Checking	Provides comprehensive drug information and checks for potential interactions.	Drug database access, interaction checker, decision support tools
Functional	Reporting and Analytics	Generates reports and analytics for monitoring and improving prescribing practices.	Usage reports, error reporting, performance metrics
Functional	Integration with Pharmacy Systems	Integrates with pharmacy management systems to streamline the dispensing process.	Real-time updates, prescription verification, inventory management
Functional	Support and Maintenance	Offers ongoing support and maintenance services.	24/7 technical support, system updates, user training

Capability Type	Capability	Description	Key Features
Functional	Compliance and Regulatory Services	Ensures compliance with healthcare regulations and standards.	Regulatory compliance, certification, policy management
Technical	Data Security and Encryption	Protects data in transit and at rest through encryption.	End-to-end encryption, data anonymisation, audit trails
Technical	System Integration	Seamlessly integrates with other healthcare IT systems.	EHR integration, pharmacy system integration, health information exchange compatibility
Technical	Reliability and Availability	Ensures high system availability with minimal downtime.	Robust infrastructure, failover mechanisms, backup and recovery systems
Technical	Scalability	Supports growing numbers of users and prescriptions.	Vertical and horisontal scaling capabilities, load balancing
Technical	User Interface	Provides an intuitive and user-friendly interface.	Clear prompts, efficient workflows, responsive design
Technical	Security and Privacy	Ensures robust privacy protection mechanisms for patient data.	Secure data storage, compliance with privacy regulations, access control

At the solution level, an ePrescription system entails a set of functionalities designed to streamline and enhance the prescription process, ensuring security, efficiency, and compliance with healthcare standards.

The functionalities of an ePrescription system, according to the literature of the selected country, are summarised below.

Table 5-7: The functionalities of an ePrescription system

Functionality	Description
User Authentication and Access Control	Ensures secure access to the system with multi-factor authentication and role-based access control.
Prescription Creation	Provides an easy and intuitive interface for creating new electronic prescriptions.
Modification and Cancellation	Allows healthcare providers to modify or cancel existing prescriptions as needed.
Electronic Transmission	Securely transmits prescriptions to pharmacies electronically to streamline the dispensing process.
Refill Management	Manages prescription refill requests efficiently, ensuring timely and accurate processing.
Patient Management	Integrates with electronic health records (EHR) to manage patient information, including medical history and allergies.
Drug Information and Interaction Checking	Accesses a comprehensive drug database to provide information and check for potential interactions.
Alerts and Decision Support	Generates alerts for potential drug interactions or allergies and provides clinical decision support tools.
Reporting and Analytics	Generates detailed reports on prescription patterns, usage, errors, and system performance.
Integration with Pharmacy Systems	Seamlessly integrates with pharmacy management systems for real-time updates and inventory management.

Functionality	Description
Security and Privacy	Ensures robust data security and privacy measures, including encryption and compliance with regulations.
User Training and Support	Offers training programs and 24/7 technical support to assist users in effectively utilising the system.
Regulatory Compliance	Adheres to healthcare standards and regulations to ensure legal compliance and data protection.
Scalability and Reliability	Supports scalability to handle growing numbers of users and prescriptions with high system availability.

5.10 Advantages and Challenges of Using an ePrescription System

The advantages and challenges of using an ePrescription system are provided below.

5.10.1 The Advantages of ePrescription

Among the advantages noted for electronic prescribing, the possibility of editing prescriptions, providing different dosages of drugs, and the impossibility of manipulating prescriptions by patients or other people were mentioned more than other advantages (Bouraghi et al., 2024).

Another advantage mentioned was the possibility of providing pre-prepared prescriptions for common diseases, which led to the acceleration of prescriptions for these diseases (Hareem et al., 2023). As an information system, the ePrescribing system can integrate with other organisational systems, such as electronic health records and pharmacy information systems, within healthcare centres like hospitals (Vejdani et al., 2022). Through the implementation and utilisation of such a system, it is possible to overcome the problems and constraints of the traditional prescribing system due to the complexity of medical care and the increase in the number of drugs, thereby benefiting from its potential advantages. The following can be reduced by using an ePrescription system (Hareem et al., 2023): Healthcare costs for stakeholders (patients, healthcare providers, insurers, and policymakers), common prescribing errors, medication outcomes, patient safety can be improved, prescriptions can be more readable and accurate, coordination among stakeholders in drug therapy can be enhanced, and clinical decision-making can be supported at the time of drug administration. (Hailiye et al., 2022; Mohsin-Shaikh et al., 2019).

Hailiye et al. (2022) add that ePrescription systems can also improve efficiency by streamlining the prescription process, reducing the time spent on phone calls and faxes between healthcare providers and pharmacies and providing clinicians with up-to-date information about patients' medications and allergies, thereby improving patient care.

Figure 5-17 summarises the advantages of ePrescription.

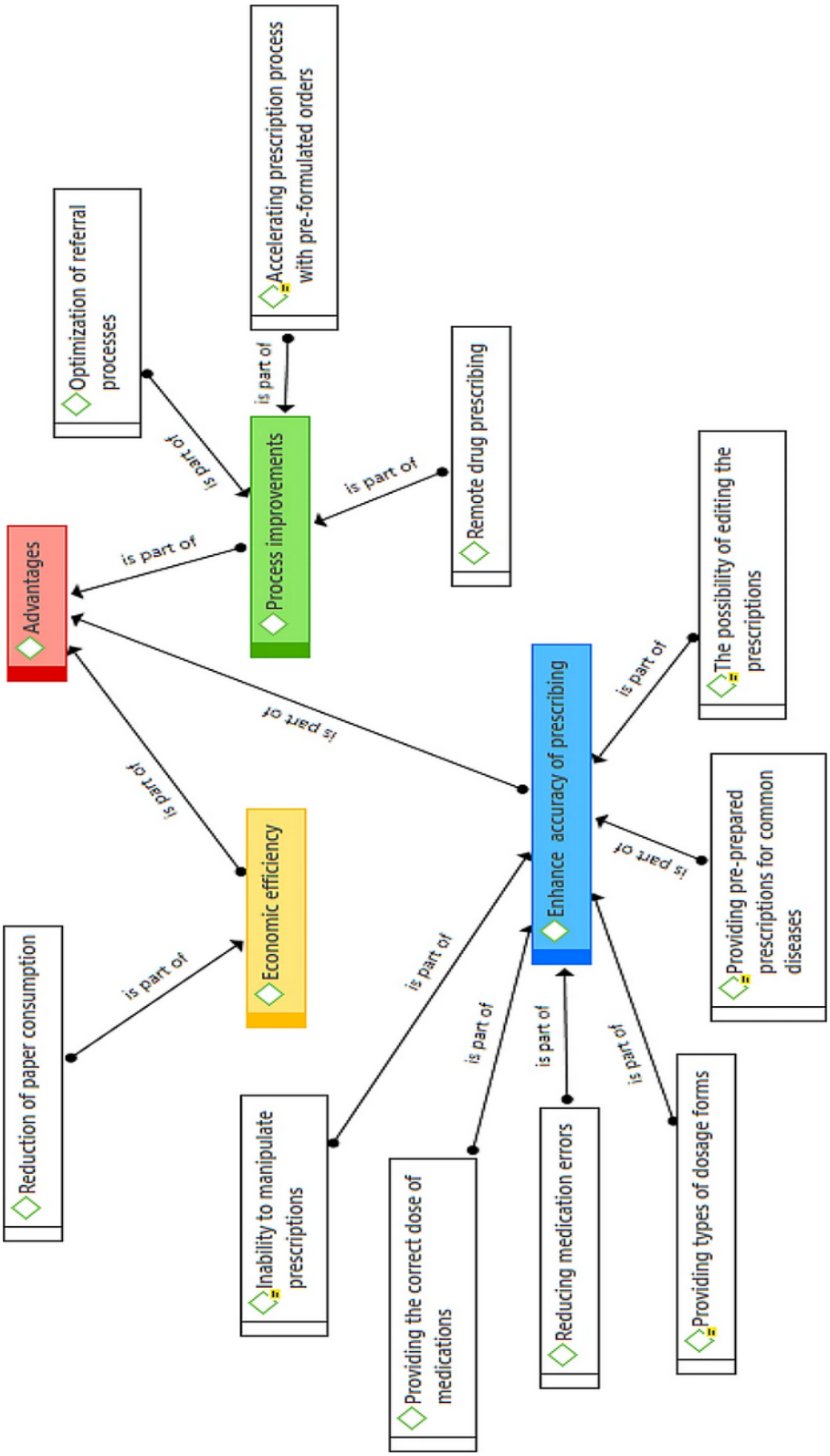

Figure 5-17: Advantages of Using ePrescription (Adapted from Bouraghi et al., 2024)

Despite the potential benefits of ePrescribing systems in the healthcare industry and significant investments and efforts by stakeholders to support such systems, their usage and adoption remain low, failing numerous implemented projects (Hailiye, 2022). Hareem et al. (2023) concur that prescribing systems improve workflow or enhance performance. There are multiple possible reasons for this, including:

- Usability issues*:* The ePrescribing system might not be user-friendly or intuitive, leading to difficulties in adoption among healthcare professionals.
- Training and support*:* There might be a lack of adequate training and support for the users, making it challenging for them to adapt to the new system.
- System limitations*:* The system might not be flexible enough to accommodate the diverse needs of different healthcare settings, leading to workflow inefficiencies.
- Resistance to change*:* Healthcare professionals, like any other group, might resist changes to established routines. This resistance could affect their perception of the system's benefits.

5.10.2 Challenges or Barriers to Using ePrescription Systems

ePrescription also poses many challenges. One of the most critical challenges is the various technical problems, including network disconnection (Bouraghi et al., 2024). Also, another big challenge that caused the dissatisfaction of the patients was the lack of skill of many physicians in working with computer systems, which led to the low speed of typing the drugs in the system and, as a result, increased the duration of the patients' visits (Oktarlina (2020, November 9). Also, many physicians may not have computer systems in their clinics, which can lead to the lack of electronic prescriptions and, as a result, the lack of use of insurance services for patients. Also, considering that many physicians are used to the paper prescription method, they are unwilling to accept and resist the changes. As a result, they needed personnel to register the prescriptions (Bouraghi et al., 2024).

Hareem et al. (2023) also add that other challenges exist, such as the costs associated with system implementation and maintenance, issues related to system interoperability, and the necessity for user training and technical support. Moreover, while these systems can mitigate traditional medication errors, they may also introduce new errors, such as those caused by user interface design or software glitches. Maximising the benefits and minimising the challenges associated with ePrescribing systems requires meticulous system design, comprehensive user training, and continuous system evaluation (Oktarlina (2020, November 9).

Insufficient bandwidth has been a significant obstacle to using ePrescribing (Bouraghi et al., 2024). This issue results in prolonged patient waiting times, leading to extended queues and decreased physician productivity. Multiple factors can cause insufficient bandwidth, such as (Bouraghi et al., 2024):

- Network Infrastructure: In areas with poor network infrastructure, insufficient bandwidth can significantly slow down the operation of ePrescribing systems, making it difficult for doctors to use them effectively.
- System Requirements: To function optimally, ePrescribing systems may need a certain level of bandwidth. System lags or downtime could result if the bandwidth is below this level.
- Data Transfer: EPrescribing systems often need to transfer large amounts of data, including patient records, prescriptions, and other related information. Insufficient bandwidth can slow down this data transfer, affecting the system's efficiency.
- Real-time Updates: Many ePrescribing systems provide real-time updates to ensure all users have the most current information. These updates can be delayed without bandwidth, resulting in potential errors or miscommunications.

Figure 5-18 illustrates and summarises these disadvantages, barriers and challenges:

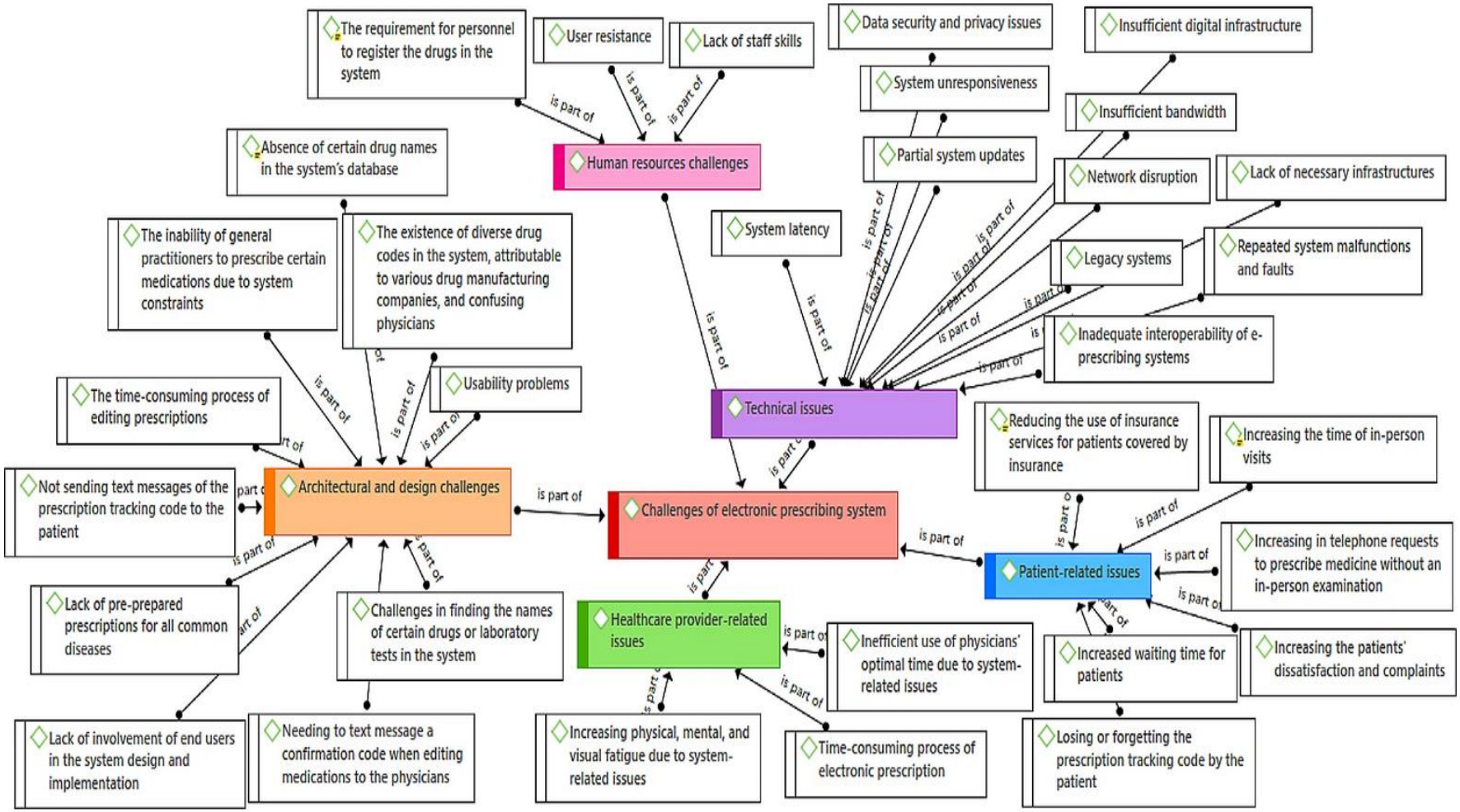

Figure 5-18: Thematic Map of the Challenges of Using Eprescription from Various Perspectives (Adapted from Bouraghi et al., 2024)

Generally, as indicated by various studies (Farida et al., 2017; Gullslett & Strand, 2022; Tamblyn et al., 2006), implementing ePrescribing systems requires robust hardware, sophisticated software, and a reliable network infrastructure.

5.11 Conclusion

Definitions of ePrescription, also known as electronic prescribing (ePrescribing), vary significantly due to the diverse technological, regulatory, and practical frameworks across different regions and healthcare systems. This variance underscores the need for a common language to ensure consistency, improve understanding, and align conversations around this complex concept. ePrescription involves healthcare providers using electronic devices to generate, transmit, and receive prescription information securely and efficiently. It can be interpreted in various ways, including using software for dispensing medicines, submitting and exchanging information among patients, prescribers, and pharmacies, direct computer-to-computer transmission, generating and sending prescription orders electronically, and transmitting information between prescribers, dispensers, pharmacy benefit managers, or health plans using electronic media. However, a universal definition of ePrescribing is not noted.

Electronic prescribing offers numerous advantages, including the ability to edit prescriptions, provide different dosages of drugs, and prevent manipulation by patients or others. It also allows for pre-prepared prescriptions for common diseases, accelerating prescriptions. Despite the potential benefits, ePrescription systems face challenges such as user-friendliness issues, inadequate training and support, system limitations and resistance to change. Costs associated with system implementation and maintenance, system interoperability issues, and the need for user training and technical support also pose challenges.

Insufficient bandwidth is a significant obstacle to using ePrescribing systems, resulting in prolonged patient waiting times, extended queues, and decreased physician productivity.

Understanding the value chain system requirements, such as patient data management, security, privacy, transparency, accountability, interoperability, and monitoring, is essential in developing an ePrescribing system. South Africa can also learn from what other countries have decided to include in their ePrescribing systems and the lessons they have learnt in this regard. ePrescribing can still be regarded as essential for the emerging South African Digital Health Ecosystem.

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Chapter 6: Conformity and Interoperability Assessment

Sibiya, G.[1]and Samson, A.[1]

[1]Next Generation Enterprises and Institutions (NGEI) cluster, CSIR.

Purpose: *In addressing the challenges of fragmented health systems in the healthcare sector in South Africa, the National Department of Health (NDoH) and the Council for Scientific and Industrial Research (CSIR) have embarked on a journey which resulted in the development of the Health Normative Standards Framework (HNSF). A testing laboratory was also developed to ensure vendor systems' conformity to the standard. The NDoH embarked on an interoperability journey since the first version of the Health Normative Standards Framework (HNSF) was gazetted in 2014 (National Department of Health, 2014). The infrastructure development enables health systems to undergo conformity assessment to fulfil the requirements stipulated in the HNSF. This chapter outlines a holistic view of the conformity assessment aspect of the interoperability journey taken by the NDoH.*

This chapter will cover the interpretation of the HL7 standards through use cases in the form of profiles developed by Integrating the Healthcare Enterprise (IHE). A selection of the profiles that are relevant and useful for the South African context was carried out. This was achieved through the localisation of IHE profiles. The NHSF localisation process started with the identification of national interoperability use cases. The linking to standards and profiles in these realisation scenarios provided guidance for building localisation and interoperable implementations. The localisation to the South African context was achieved by developing national specifications based on the prioritised use cases. The national specifications were shared with the health system vendors, and the selection of profiles needed to be relevant and useful to the South African context. The national specifications were shared with the health system vendors so that they could develop systems that adhere to these specifications. The specifications were implemented in a conformity assessment digital health innovation testing laboratory, which enabled interoperability assessment to ascertain systems readiness to integrate with other health systems in the NDoH ecosystem.

The conformity assessment to IHE profiles on health systems at the international level is performed by IHE-accredited laboratories. This poses a challenge for South African vendors due to fees associated with the assessment activities. The initiative is meant to allow South African vendors to assess their system's conformity to HNSF, allowing them to interoperate with other health systems within South Africa.

Study design/methodology/approach: *The approach in this work was both explorative and experimental. The explorative aspect included reviewing existing standards as in the HNSF*

catalogue. The experimental aspect included defining and incorporating localised specifications into the conformity assessment infrastructure. This started with the HL7v2-based profiles (HL7, 2011) and later, FHIR-based profiles. Three external systems from Free State, Gauteng and KwaZulu-Natal provinces of the Department of Health were taken through the conformity assessment process and based on the assessment outcomes, they were approved to be integrated with the Health Patient Registration System (HPRS).

Findings: *This study was conducted with three vendors. The NDoH facilitated the selection process. The participating vendors were required to register their systems on the Gazelle Test Bed to conduct the conformance testing. The vendor's systems were configured to perform peer-to-peer testing. The vendors had the opportunity to test the profiles of ATNA, CT, and PDQ. Each vendor was provided a test report at the end of the testing session. This demonstrated the capability to perform assessments locally in a cost-effective manner. Additionally, this allowed the vendor health information systems to integrate with the HPRS.*

Originality/value: *Information exchange amongst the systems built with diverse technology frameworks is critical and of value for both the health service recipients and service providers. Beneficiaries will not need duplicate information sitting in isolated systems in every health facility they consult. Setting up a conformance laboratory enables systems to ascertain their capability to share or consume information with another health system in a standard way. If this is done correctly, it will decrease the fragmentation of these health systems.*

Keywords: *Conformity assessment, HL7v2, FHIR, Interoperability, Certification, ATNA, CT, PDQ*

6.1 Introduction

IT systems are the foundation of patient management systems. The healthcare system is characterised by fragmented health information systems and a lack of interoperability (Chuma & Sibiya, 2022). There is a lack of seamless, secure, and reliable integration and sharing of health information or data across devices, systems, components, and business processes. The National Department of Health (NDoH), in collaboration with the Council for Scientific and Industrial Research (CSIR), has established a digital health innovation testing laboratory to bridge a gap between systems that are not communicating. Before the implementation of this testing laboratory, a desktop study was conducted to ascertain the companies that have carried out this initiative. The study has shown that the Integrated Healthcare Exchange (IHE) has a working and established conformity assessment testing laboratory infrastructure. In preparation for establishing the digital health innovation laboratory, the CSIR has had numerous consultations with IHE-Europe since the IHE has been a role player in promoting health information technology (HIT) interoperability. The

role of the IHE is to assess interoperability for national e-health projects, HIT users in regional hospitals, and suppliers developing new platforms (IHE, 2024a). The purpose of the consultations was to fast-track the learnings in setting up a digital innovation testing laboratory infrastructure for South Africa.

Adebesin, Foster, Kotzé and Van Greunen (2013) argue that the current landscape of eHealth systems in South Africa is characterised by the system vendors not adhering to implementation guidelines when developing health systems. This was due to the absence of standards for South Africa (Adebesin et al., 2013). The adoption of standards worldwide has been the biggest hindrance to achieving interoperability in health systems. This results from standards not being clearly defined (Oemig & Snelick, 2016). The NDoH has bridged the gap by developing a Health Normative Standards Framework (HNSF), which prescribes standards by which eHealth systems must conform in South Africa. The gazette states that any patient information system in the South African health sector should comply with the standards described in the Health Normative Standards Framework (HNSF) (NDoH, 2021). The HNSF (NDoH, 2021) prescribes IHE profiles and associated standards that should be adhered to when implementing specific eHealth functions for South Africa. This was followed by developing the localised national specifications issued to Health Information Systems (HIS) vendors.

HIS vendors need proof that their products conform to health standards. This can be proven through a formal process such as conformance and interoperability testing. However, this posed a challenge for the South African eHealth systems because they could only test their conformance through IHE Connectathons hosted by international companies such as IHE-Europe. This was so because there was no local infrastructure to fulfil the purpose. Due to the immediate need, the NDoH and CSIR have prepared an infrastructure to assess vendor systems for their compliance with the HNSF, indicating their readiness to interoperate with other systems in the South African ecosystem.

The Council for Scientific and Industrial Research (CSIR) began by configuring a testing suite known as a Gazelle platform, which was adopted as the fundamental tool for assessing the interoperability of eHealth information systems in South Africa. The Gazelle platform utilises a set of open-source tools (Developed under the Apache 2.0 license) maintained by IHE Services; they also provide additional value-added services for the enterprise edition of IHE Gazelle (IHE, 2024b).

The chapter is organised as follows: The first section focuses on the theoretical background which underpins the presented work, followed by discussions on the strategies and approaches and the key principles underpinning the approach. The application of interoperability testing in the South African healthcare systems is provided before discussions on aligning the digital conformance testing laboratory with the South African Digital Health Strategy (NDoH, 2019a) are highlighted. The benefits and challenges and the user-centred perspective are discussed before focusing on the

implementation guides and the critical analysis of the findings from the work presented in this chapter.

6.2 Theoretical Background

According to Mamuye, Yilma, Abdulwahab, Broomhead, Zondo, Kyeng, Maeda, Abdulaziz, Wuhib and Tilahun (2022), South Africa is advancing in developing local technologies. However, those technologies are still operating in silos, and this results in health data being disintegrated (Mamuye et al., 2022). Healthcare systems in South Africa are siloed, and they operate independently.

This enacted the establishment of the Health Normative Standards Framework, which prescribes standards through which systems can interoperate. Adopting international standards does not fulfil requirements for individual countries with differing demographics and socio-economic needs. The IHE permits other countries to leverage the existing IHE integration profiles and standards in any way they wish to improve their health systems' capabilities (IHE, 2024c). As presented by Bojanowski, Radomski, Grudzien, Matras, Masiarz, Lanko, Poland (2018) is an example of a country that took advantage of the IHE integration profiles and tools to implement their national healthcare interoperability specifications (Bojanowski et al., 2018). Since the HNSF was gazetted in South Africa in 2014, followed by the second version in 2021 (NDoH, 2021), no initiative has been put in place to assert systems for their compliance with the framework except for the work presented in this chapter.

The HL7 international standards and integration profiles for specific countries are implemented through localised specifications. The localisation aspect of the South African conformity and interoperability assessment lies in the value sets (HL7, 2024). The localisation through value sets is not limited to Language but also acceptable values at the regional or country level. This allows localisation to be based only on specifications rather than a localised standard or integration profile version.

The localised national specification dictates the mandatory fields. The vendors implementing the health information systems in South Africa were required to implement their systems as per the requirements in the national specifications. This was to ensure that their systems adhered to these implementation guidelines and enabled them to consume information through the source system. Any system that needed to integrate with the source system was required to use the national specification to implement their systems. In the South African context, querying by date of birth was mandatory. According to Oemig and Snelick (2016), the HL7 standard states that the date of birth is not mandatory (Oemig & Snelick, 2016). This is an example of the localisation implemented in the current work for the South African context. For any application that seeks to comply with the national specifications, that application will need to implement and support patient demographic query (PDQ) and similarly, the patient demographics consumer (PDC) will need to adhere to these minimum requirements. The HL7 and FHIR support searches by partial

parameter values and wildcards. The IHE integration profiles do not specify matching requirements such as partial matching (IHE, 2023b). The patient demographics source systems enforce this, and the error response is supported when the search parameter is incorrect.

This section presented initiatives from the international level that seek to enable interoperability and conformance assessment capabilities. The section also presented healthcare interoperability standards that were considered in the current work. The following section presents the strategy through which the standards were adopted, considered and enabled for conformity and interoperability assessment in South Africa.

6.3 Strategies, Approaches or Experiences Description

In order to achieve a conformity assessment in South Africa, relevant and useful profiles were selected based on the national priority use cases in the current study. A process of localisation of IHE profiles followed the selection of the profiles. Based on the South African needs, the researchers were guided by the current initiatives regarding which profiles to adapt and account for. The priority use cases required minimal ability to exchange patient Table 4-1 demographics information. With this as guidance, profiles that would enable seamless and standards-based auditing and logging of secure exchange of information were needed. This need was addressed by the minimum of the three selected profiles: ATNA, PDQ and CT. The linking to standards and profiles in these realisation scenarios guided building localisation and interoperable implementations.

The systems that needed to comply with the HNSF had to ensure that they followed South African implementation guidelines. A list of fields that need to be supported by applications to conform with the South African specifications is presented in Table 6-1.

In the table, the optionality R, stands for Required. Other options supported by the standard and the integration profiles are R2, O, R+ and C. R2 is an IHE extension where if the sending application has data for the field, it is required to populate the field. R+ is an IHE extension. This is a field that IHE requires but is listed as optional within the HL7 standard. O and C stand for optional and conditional, respectively.

Table 6-1: Mandatory PID Elements for the South African Context

HL7 V2 Data Elements	Data element name	Optionality	Constraint
PID 5.2	Patient name	R	The first repetition shall contain the legal name. Spaces separate multiple given names
PID 5.1.1	Patient Surname	R	Required, Family name
PID 3.1	Patient Identifier- ID number	R	Required, South African Identification number

HL7 V2 Data Elements	Data element name	Optionality	Constraint
PID 3.4.1	Patient Identifier-Patient Reference Number number	R	Required, healthcare unique patient identifier
PID 7.1	Date/Time of Birth-DOB	R	Required, must have month, day, and year
PID 8	Administrative sex	R	M=male, F= female, U= unspecified/unknown
PID 11.1	Address	R	The mailing address of a patient.

The localisation to the South African context was achieved by developing national specifications based on the prioritised use cases. The national specifications were shared with the health system vendors.

Even though there are no deviations from the IHE profiles, localised specifications imply that any system that implements and is verified to conform with the localised specifications is only valid in the South African context. If the system is intended to be deployed outside of South Africa, it would need to be assessed based on the international specifications by the IHE or other international bodies.

The HNSF prescribes the IHE profiles that must be implemented in South Africa based on prioritised use cases. According to the HNSF, there is a need to localise these use cases to the South African Context (NDoH, 2021). The IHE provides the profiles, international standards, and open-source tools to evaluate systems for conformity assessment. The standards adopted for the South African context were Health Level Seven (HL7v2) and Fast Healthcare Interoperability Resources (FHIR). The establishment of the eHealth laboratory needed to be configured to allow for the realisation of conformity assessment. The researchers looked at existing tools that could be used to support the initiative. Based on the desktop study conducted, the Gazelle test suite was selected as a platform to manage and execute those profiles.

Other tools that could have been selected include tools by the National Institute of Standards and Technology (NIST). However, NIST did not provide the tools for local deployments. South Africa opted to use IHE tools such as the Gazelle. IHE allows companies to leverage their Gazelle open-source infrastructure and localise it according to the countries' needs. The Gazelle infrastructure was configured to implement a digital health conformance laboratory in South Africa. The sequence diagram in Figure 6-1 shows how the system under test (SUT) should be configured. In this case, SUT refers to any vendor system that will be tested for conformance. In the figure, the gazelle tools (IHE, 2024b), which are the Gazelle Test Manager (TM), Gazelle External Validation Service (EVS) Client and the Gazelle Proxy, are the IHE components that were deployed locally to enable customised and localised interoperability. In this case, the Health Application Programming Interface (HAPI) client is a placeholder for a SUT. These are clients, Patient

Demographic Consumers (PDC) meant to consume patient information from a supplier. The Patient Demographic Supplier (PDS) used for all our tests is the HPRS, as shown in Figure 6-1. The system users for both the SUT and the lab systems are shown as the monitor role and the system owner/operator, as shown in Figure 6-1.

In the diagram, there are different actors, including users and systems. The system owner represents a person whose system is being tested. The monitor represents someone responsible for checking whether the tests are failing or passing. This person also provides guidance where necessary. The Gazelle- TM, Gazelle EVSClient, PDC HAPI, Gazelle- Proxy, and PDS HPRS are all actors in the form of applications. Each application plays a different role. The first component after the users is the Gazelle Test Manager (TM). The component manages all data related to test sessions, system vendors, system information and grading tools related to a test activity. The Gazelle EVS client checks the validity of exchanged messages against a predefined message schema that conforms to a specific standard or profile. The Patient Demographics Consumer (PDC), represented by a HAPI client, is a system which consumes patient information by sending queries to the Patient Demographics Supplier represented by the HPRS in Figure 6-1 if the PDC requires the patient demographics information.

The components in their entity represent a real-life scenario where a patient visits a healthcare facility. Their information is pulled from a national patient information system regardless of the location in the country or where they historically visited healthcare facilities.

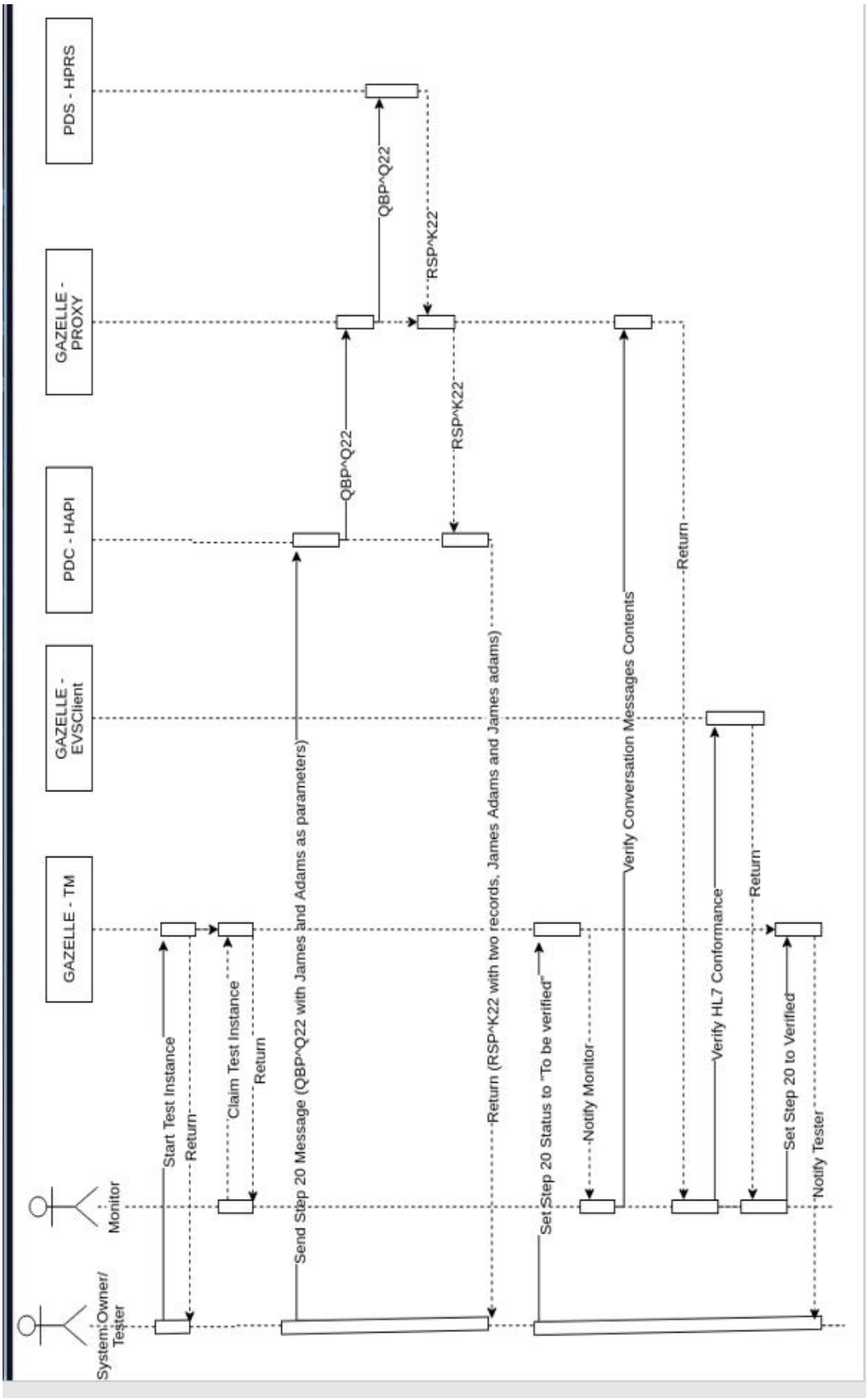

Figure 6-1: Conformance Laboratory Sequence Diagram

The section explains the approach to undertaking the conformance and interoperability of vendor systems in South Africa. It further highlights the localisation aspects of the national specifications for South Africa. The following section will address the principles underpinning vendor health system's conformity and interoperability assessment.

6.4 Key Principles Underpinning the Approach

To guarantee interoperability, systems ought to undergo conformance testing, which verifies their compliance with standards and profiles, as well as cross-system interoperability testing, typically conducted during peer-to-peer testing events or connectathons.

- Accreditation in the field of interoperability serves as a measure of successful testing, and to satisfy standards-based profile testing requirements, testing must be founded on thorough and well-defined implementation testing as well as appropriately defined test case scenarios.
- As a result, thorough compliance testing tools and clearly defined processes are required.
- When system modifications impact or involve data connected to the shared infrastructure, compliance certificates are granted based on specific software versions that must be reissued.

The section presents principles underpinning vendor health systems' conformity and interoperability assessment. The following chapter will address the application of conformance and interoperability testing in South Africa and explain why the work scope is confined to three vendor systems.

6.5 The Application of Conformance and Interoperability Testing in the South African Context

The interoperability specifications defined in the HNSF are directly related to the business use cases and specify the standards-based IHE profiles as well as their underlying norms and supporting standards per generic eHealth function (NDoH, 2021). The integration and content profiles are considered the most practical layer for performing interoperability conformance testing. A need-based approach for the selection of the use cases was done. The NDoH's authoritative source of patient information system is called the Health Patient Registry System (HPRS), which stores patient demographic details that guided this decision. This has put the CSIR implementation team ahead in establishing the digital health innovation testing laboratory because an existing information system that provides patient demographic details was already established. The HPRS was configured to be a Patient Demographic Supplier and became the primary source for patient demographic data. This system was set up to function as a supplier throughout the process. A requirement set by the department is that external systems must pass a conformance and interoperability assessment to guarantee that they are compatible with HPRS for information exchange.

Localised specifications have been developed and issued to HIS vendors interested in integrating with the HPRS. Three vendor system indicated their need and readiness to integrate with the HPRS. The request of these vendors was conveyed to the CSIR by the NDoH. The CSIR researchers could only test vendor systems that the department permitted. The KwaZulu Natal, Eastern Cape and Gauteng health departments were granted permission to undergo conformity and interoperability assessment. These systems had to register their systems under test (SUT). Some guidelines were followed to register a SUT. Firstly, before HIS vendors get access to the digital health innovation testing laboratory, the owners of those systems need to follow a formal process of sending a request to the NDoH. Once that request is granted, the NDoH will communicate with the CSIR and provide the contact details of the HIS vendor. The CSIR would then contact the vendor to prepare for the integration process.

Once the HIS vendors were deemed ready to perform conformance and interoperability testing, they would get access to test cases. These test cases are embedded in the Gazelle test bed. The test case specifications detail a test description, test methods, test profiles, test procedures, test cases, and test scripts. They also provide the structure of messages that need to flow between the two systems. Below are examples of a PDQ (IHE, 2023a) request and response messages while querying for patient information from the HPRS by the consumer (health information system vendor).

The query messages

```
MSH|^~\&|PatientManager|IHE|HPRS|HPRS|20170425163203||QBP^Q22^QBP_Q21|20170425163203|
P|2.5                                                                    QPD|Q22^Find
andidates^HL7|849476410130366166890645833527|@PID.3.1^9212078045186~@PID.3.4.1^DHA
~@PID.3.4.2^www.home-affairs.gov.za~@PID.3.4.3^DNS RCP|I
```

The response messages

```
MSH|^~\&|HPRS^^|HPRS^^|PatientManager^^|IHE^^|201811151135||RSP^K22^RSP_K21|1542627611
9569 65|P|2.5 MSA|AA|20170425163203 QAK|849476410130366166890645833527|OK
QPD|Q22^Find
Candidates^HL7|849476410130366166890645833527|@PID.3.1^9212078045186~@PID.3.4.1^DHA
~@PID.3.4.2^www.home-affairs.gov.za~@PID.3.4.3^DNS PID|||2540c604-919a-11e8-9078-
0b1629b16d1a^^^HPRS_PATIENT_UUID&hprs.health.gov.za&DNS~9212078045186^^^DHA&www.h
omeaffairs.gov.za&DNS^NNZAF~138-135-
1640^^^DOH&www.health.gov.za&DNS^NH^^20180727~138-135-
1640^^^DOH&www.health.gov.za&DNS^MR^735042^||adams^James^^^^^U||19921207|M|||DFASFA^^
Newcastle^^2954^ZA||^^^rbronkhorst@meditech.co.za^^^^^^^^0827483691||||||||||||||||UN NZAF
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At the time of writing, three vendor systems presented by three provincial departments had been taken through the conformity assessment in South Africa. The provincial departments would approach the NDoH to request linkages with the HPRS. Upon receipt of the request, the NDoH will facilitate a formal request to the CSIR. The selection process was not about sampling a particular system, it was per-need-based for the systems to integrate with HPRS. This led the CSIR

to be able to assess only three vendor systems. The presented systems were from the Free State, Gauteng, and KwaZulu-Natal provinces. During the conformity assessment, the systems were configured as consumers that queried HPRS for patient demographics. Peer-to-peer testing was conducted. All these systems were able to exchange information. At the end of the testing session, all three vendors were issued a report summarising the conformity assessment based on the HNSF specifications. In addition to the PDQ profile, the Audit Trail and Node Authentication (ATNA and the Consistent Time (CT) profiles (IHE, 2023a) were assessed as a criterion for conformance with the HNSF.

The future work for a broader inclusion or representation of the more comprehensive range of health systems' assessment in the country, the plan would be to have an open call for all the health systems that want to be assessed, and the CSIR would conduct connectathons and projectathons.

In the next section, details on how the approach is in line with the South African digital health strategy are presented.

6.6 Alignment with South African Digital Health Strategy

The approach in this work was both explorative and experimental. The explorative aspect included reviewing existing standards such as the HNSF catalogue and the National Department of Health's digital health strategic objectives (NDoH, 2020). The current work considers the Patient Demographic Query (PDQ) profile for demographic information exchange. The Node Authentication and Audit Trail (ATNA) and the Consistent Time (CT) profiles were considered for secure and audited communication between suppliers and consumers of patient information. The profiles are also essential to ensure the privacy of the data subjects. It is also worth mentioning that no real patient data was utilised during the testing process. The only minimal personal information captured was the contact details of the system vendor representatives. The ethical aspect of the consent testing process is implied since the system owners are the ones who provide their information by themselves. The information is only for conformance testing purposes and is not intended to be used outside the conformance assessment jurisdiction.

During the execution of conformity and interoperability assessments, the Health Patient Registration System (HPRS) was used to supply patient information. Solomon, Chetty, and Venter (2014) state that the HPRS results from the NDoH's initiative to provide an authoritative source of patient information.

As an authoritative source of patient information, the HPRS needed to make patient information available in a standard format. The consumers of the patient information also needed to do it in a standard HNSF-specified format that the HPRS accepted. Therefore, to ensure interoperability between the consumers and the HPRS, both the HPRS and the consumers must comply with the HNSF, which provides the standard message format and structure specifications.

A mechanism was then required to assert whether the HPRS and the consumer systems conform to the specifications in the HNSF. An HNSF conformity assessment laboratory can fulfil this requirement, and it has become part of the strategic intervention in the National Department of Health's 2019-2024 Strategy (NDoH, 2019).

In the NHI white paper, the HPRS is described as the system that provides Patient Registry and Master Patient Index services that have been rolled out to public PHC health facilities (NHI, 2015). The HPRS has been developed to provide a patient registry and MPI using the South African identification number and other legal person identification systems such as passports (Department of Health, 2019). The HPRS is, therefore, the definitive source of patient identity and demographic information within the South African public health system. The current mechanism for patient identity and demographic information management in public PHC facilities is provided by the HPRS front end. The HPRS front-end is a system enabling personnel at health facilities to verify patient identity, register patients, manage their identity and demographic information and record visits to facilities by the patient. The HPRS also generates a globally unique Patient Record Number (PRN) that is used for all eHealth transactions. A patient information system operating within the public health environment will be required to query the HPRS through a standards-based interface described in the HNSF (NDoH, 2021) for the current patient identity and demographic information. The Patient Reference Number assigned by the HPRS to the patient should be stored by the patient information system and used as a reference in further eHealth transactions and communications.

6.6.1 Patient Demographic Supplier and Patient Demographic Consumer

There are two actors in the *Patient Demographic Query* profile, namely:

6.6.1.1 Patient Demographic Supplier (PDS):

A system responsible for adding, updating and maintaining demographics about a patient, and additional information such as related persons (primary caregiver, guarantor, next of kin, etc.). It supplies new and updated information to the Patient Demographics Consumer. The Patient Demographics Supplier receives patient registration and update messages from other enterprise systems, probably due to PIX messages. It then responds to queries for information submitted by Patient Demographics Consumers. It then returns demographic information from the single domain associated with the application to which the query message is sent. An example of a PDS is HPRS.

6.6.1.2 Patient Demographics Consumer

This system uses demographic information about a patient provided by the Patient Demographics Supplier. The Patient Demographic consumer requests a list of patients matching a minimal set of

demographic criteria (e.g. ID, name, surname, address, etc. from the patient demographic supplier. An example can be any vendor health information system that consumes information from HPRS.

6.6.2 Conformance Assessment vs Interoperability Assessment

Conformance testing captures technical descriptions of a specification through automated or manual means or a combination and determines if an implementation completely implements procedures or functions by the specification (NIST, 2009).

The International Organisation for Standardisation (ISO) describes conformity assessment as an area of standards development that covers activities used to ensure that products, processes, services, persons, systems and bodies meet requirements specified through standards. The activities include testing, inspection, evaluation, examination, auditing, assessment, declaration, certification, accreditation, peer assessment, verification and validation (ISO, 2009).

Lipman, Palmer and Palacios (2011) describe conformance testing as a way of verifying implementations of a specification to determine whether deviations from the specification exist. When all deviations and omissions are eliminated, the implementation conforms to the specification (Lipman et al., 2011). Lipman et al. argue that, while conformance testing focuses on the specific requirements of a standard, interoperability testing examines characteristics related to how information is exchanged between systems.

This means that, though systems can communicate among themselves within a specific domain without them being implemented according to the specification and asserted through conformance testing, it does not prove that the same systems can out the closed environment using the specific standard.

The conformance and interoperability approaches were followed in the South African context. The conformity assessment aspect focused on whether systems could exchange messages in a PDQ format and secure using the ATNA profile as a criterion. This did not mean that the systems conformed to the respective profiles, as an IHE-accredited laboratory would need to assess this. The assessment only meant that the systems conformed to the specifications or requirements of the HNSF and were only valid within the South African context. To perform a conformity assessment to the IHE profiles, a laboratory must be ISO-certified and accredited by the IHE. At the time of the current publication, only the initial stages of getting accredited were initiated, which included the ISO 17025 training.

Other activities include the experimental aspect, which includes defining localised specifications and incorporating them into the conformity assessment infrastructure. This started with the HL7v2-based profiles and later, FHIR-based profiles. The CSIR has looked at three specific profiles namely:

- Patient Demographic Query (PDQ) (HL7v2 and FHIR).

- Audit Trail and Node Authentication (ATNA).
- Consistent Time (CT).

For each of the profiles listed above, localised specifications were developed. The specifications are used as a South African localised criterion to assess systems for their conformance to the HNSF and their ability to interoperate with other health systems within the South African context through the HNSF (NDoH, 2021). The specifications and the gazelle user manual were sent to the vendors interested in connecting with the HPRS. The vendors would configure their systems per the guidelines provided, and the CSIR technical team supported them. Upon setting up their infrastructure, the vendors would be assessed through conformity assessment readiness, where the CSIR team checks if their systems can tick all the required checks. The vendors were invited to perform the interoperability testing upon the system passing the readiness assessment.

Three external systems from Free State, Gauteng and KwaZulu-Natal provinces of the Department of Health were taken through the conformity assessment process and based on the assessment outcomes, the NDoH on whether to allow the systems to be integrated with the HPRS (Solomon et al., 2014).

The next section addresses the benefits and challenges of enabling conformity and interoperability assessment in South Africa.

6.7 Benefits and Challenges

This section explores the benefits and advantages of enabling conformity assessment in South Africa. It also addresses challenges or barriers with enablement of the conformity and interoperability assessment in South Africa. The benefits are presented by considering individual beneficiaries and how they benefit from the enablement of conformity and interoperability assessment in South Africa. The beneficiaries of the conformity assessment initiative include the NDoH and the HIS vendors. The benefits of adopting the Conformance testing laboratory in the South African digital landscape can be categorised as follows.

6.7.1 Financial Benefits

Establishing the conformance testing laboratory in South Africa has the potential to raise revenue. South Africa lacks an accredited conformity testing laboratory. South African HIS vendors must conduct conformity testing through IHE, which has cost ramifications for them. Conformance testing within South African borders may reduce the vendor's fees for undertaking conformance testing via the IHE, including travel and Connectathon fees. Similarly, the SA conformance testing laboratory may charge a percentage fee to HIS vendors who wish to undergo conformity assessment.

6.7.2 Health Systems Vendors

The proposed system benefits the vendors by providing an infrastructure to prove their ability to connect and communicate through the standards specified in the HNSF. This can then be used as one of the criteria for eligibility to be integrated into the national health information systems. Below are the benefits for the HIS vendors:

- Access to the Conformance testing lab within South African borders.
- Increases the interoperability readiness for systems and solutions.
- Enhances credibility by differentiating the company and its products, potentially leading to greater avenues of being contracted.
- Increased possibility of connecting with national health systems.

6.7.3 National Department of Health (NDoH)

The NDoH retains responsibility for selecting solutions that can be integrated with existing national health information systems. The suggested infrastructure will continue to be utilised as a scientific criterion to determine whether systems can interact with national health systems.

6.7.4 Barriers to the implementation of conformance testing laboratory.

Malakoane, Heunis, Chikobvu, Kigozi and Kruger (2020) argue that most health systems are fragmented, and the implementations of these systems are not standard-based (Malakoane et al., 2020). Systems at different levels of government interoperate based on peer agreements on how messages are to be formatted and exchanged. It can be challenging for system vendors to migrate their legacy systems, which may vary from expert funding for migration projects to compliance. This can invest in a conformity and assessment laboratory not to be profitable in the short term. However, once the standards are adopted and new systems are developed with standard compliance, investing in a conformity and interoperability assessment laboratory can have financial benefits.

The following section addresses how individual users can benefit from implementing the conformity and interoperability assessment capability.

6.8 The Conformity Assessment from a User Perspective

The major challenge is health system vendors' inability to share information with systems beyond what they initially intended to share information with. Modifications often need to be made to share with additional systems to interoperate with new systems. The HNSF addresses this challenge and, the conformance laboratory testing infrastructure enables vendors to assess their system on their conformance to the HNSF and, hence, their ability to interoperate without any modifications. Gebase, Snelick and Skall (2008) argue that, although applications can be

developed using the same standard, there is no assurance that these applications will work together seamlessly. Another problem might be that even if a standard is in place, some applications might not be able to apply it correctly (Gebase et al., 2008). Conformance testing is the only method to determine whether standards are implemented correctly. While it doesn't guarantee interoperability, it does raise the likelihood of interoperability.

With interoperable health systems, healthcare professionals benefit from implementing conformance testing in that they can purchase ready-made eHealth systems. The new systems have undergone conformance testing, ensuring they won't encounter difficulties when adding additional applications to the current systems. This will eliminate the need for them to purchase systems that are difficult to integrate or always be trained on new systems that are already integrated.

This strategy will also help vendors because it will lend credibility to their products, making them more marketable on a national level due to compliance with HL7 and IHE profiles. Vendors would only need certification from the IHE to compete at the international level. There won't be any restrictions on the size of the market.

The medical aid industry systems can be integrated with hospital networks and allow information exchange. Through this, the patient, as the end user, benefits by having their information readily available at the point of service, regardless of their location in the country. The patients would also have a comprehensive view of their medical information, unlike the fragmented view that occurs when systems are isolated.

The next section presents considerations for implementing the conformity and interoperability assessment infrastructure.

6.9 Conformity Assessment Implementation Guidance

This section presents lessons learned in developing and enabling conformity and interoperability assessment in South Africa. Initially, the authors aimed to provide an infrastructure that would cater to conformance and interoperability testing based on the HNSF standard. However, the ultimate objective was for third-party systems to interoperate with the national health systems. Given the fact that, even if two systems may implement the same standard, it does not mean that they can interoperate, and the reverse is true, interoperability testing, interoperability testing became a necessity.

To conform to IHE profile testing capability, the laboratory and personnel must be ISO 27025 certified (ISO, 2023). As the HNSF is mainly based on the IHE profiles, IHE authorisation was required for the laboratory to conduct conformance testing of the profiles. While preparations for accreditations by the IHE, the interoperability testing was conducted through the HNSF laboratory.

Some of the lessons learned from this approach are that vendors need a platform through which tests can still be conducted throughout the development phase of their product.

In the next section, the chapter results and analysis are presented.

6.10 Results and Analysis

This chapter presented an approach to enable conformality and interoperability assessment based on the Health Normative Standards Framework (HNSF). The HNSF is aligned with the South African Digital Health Strategy 2019-2024. To facilitate the implementation of HNSF prescripts by national and private healthcare systems, a conformity and interoperability assessment capability was required in South Africa, and this is the contribution of the work presented in this chapter. A similar initiative in Poland was considered, where the IHE open-source tools and the IHE integration profiles were adopted. The current work focuses on the South African context and aims to enable the implementation of the HNSF. This means that a system that has been assessed through the service presented in this chapter cannot claim conformance to the IHE International's integration profiles. For conformance to the integration profiles, the system would still need to be assessed through the IHE International's accredited facilities.

The current work has demonstrated the ability of systems to assert their conformance to the HNSF through the adoption of tools made available by the IHE. Further improvements in the capability can come through the utilisation of the service. At the time of writing, only three systems have been taken through the assessment process for conformity to the HNSF prescripts. Work is underway to develop strategies to improve service utilisation, including interoperability testing through country-level Connectathons.

6.11 Conclusion

This chapter presented the conformity and interoperability assessment platform as part of the strategic interventions by the NDoH. The conformity and interoperability assessment laboratory allows eHealth system vendors to assess their system's compliance with the Normative Health Standards Framework (HNSF). The chapter presented how conformity and interoperability on standards specified in the HNS were enabled through the laboratory. It also presented systems that have already been taken through the conformity and interoperability assessment. This allowed the NDoH to objectively determine if a vendor system can be integrated with the national health patient registration system based on its ability to interoperate in a standard compliant way. This conformity assessment initiative will help the systems assert their conformity to the HNSF and, in turn, their ability to interoperate with other systems.

The current implementation of the conformity assessment platform was based on the HL7v2-based IHE profiles. More support for *Fast Healthcare Interoperability Resources* (FHIR)(HL7, 2023) based profiles will be supported in future work. Investigations are also ongoing on how the

conformity and interoperability assessment laboratory can support initiatives by the World Health Organisation on SMART guidelines (WHO, 2022) and turn the Computable Care Guidelines (IHE, 2020).

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Section B: Approaches

Prof. M.E. Herselman

In digital health, the path to innovation is paved with strategic approaches. This category delves into the methodologies, frameworks, and tactics that shape the adoption and integration of digital health solutions in South Africa. These chapters showcase the diverse approaches that drive healthcare delivery transformation from user-centric design principles to agile implementation strategies. As you delve into this section, prepare to embark on a journey through the innovative approaches shaping the future of digital health in South Africa.

Chapter 7: Implementing Digital Health Solutions in South Africa: A Case Study of the Positive Infusion Strategy for HPRS Deployment

Wolmerans, M.[1] and Rousseau, P.[1]

[1] Health Systems - Digital Information: National Department of Health

Purpose: *The purpose of this study is to describe the conceptualization, design, and application of the Positive Infusion Strategy, which facilitated the implementation and adoption of the Health Patient Registration System (HPRS) across Primary Health Care (PHC) facilities in South Africa. The strategy aimed to improve patient management and data collection as part of the larger National Health Insurance Information System (NHI-IS) initiative, aligning with national goals to enhance healthcare delivery and universal health coverage.*

Study design/methodology/approach: *The study utilizes an analytical narrative case study, following the experiences of implementing the HPRS across 1,500 PHC facilities. A process-tracing research design approach adapted from Beach and Pedersen (2013) is employed to examine the mechanisms that generated outcomes within the context of the South African public healthcare system. This approach involves in-depth descriptions of the stages of implementation, including stakeholder engagement, capacity building, and change management.*

Objectives: *The main objective of this study is to explore how the Positive Infusion Strategy effectively facilitated the rapid deployment and institutionalization of the HPRS. The study aims to provide practical insights into the challenges faced, the strategies employed to overcome these challenges, and the overall impact on healthcare delivery and data management at the PHC level.*

Findings: *The study finds that the Positive Infusion Strategy significantly enhanced the adoption of the HPRS by fostering stakeholder buy-in, providing comprehensive training and support, and enabling flexibility to address local challenges. The outcomes include reduced administrative burdens for healthcare workers, decreased patient wait times, and improved data accuracy and reporting. The study emphasizes that while technology is crucial, the success of digital health initiatives is largely dependent on change management processes and continuous capacity building.*

Keywords: *Health Patient Registration System (HPRS), Positive Infusion Strategy, digital health, Primary Health Care (PHC), South Africa, National Health Insurance (NHI), healthcare delivery, stakeholder engagement, process tracing, health information systems.*

7.1 Introduction

This study is guided by the mandate of the National Department of Health (NDoH). According to Section 74 of the National Health Act, the NDoH is tasked with facilitating and coordinating Health Information Systems. Several key policy documents provide direction for this mandate. First is the District Health Management Information Systems (DHMIS) Policy (2011), which outlines the requirements for health information systems at the national, provincial, district, sub-district, and health establishment levels. It also specifies that the NDoH's Director-General of the NDoH retains overall ownership of the DHMIS. Second is the eHealth Strategy (NDoH, 2012), which outlines a roadmap for a National Integrated Patient-Based Information System. Third is the White Paper on National Health Insurance (NDoH, 2015), which aims to establish universal healthcare. The National Health Insurance (NHI) was proposed in the 2011 Green Paper and outlined a phased implementation over 14 years starting in 2012. The White Paper published by the Department of Health in 2015 provided a framework for stakeholder submissions. The finalized White Paper, signed off in June 2017, incorporated updates reflective of the current state of healthcare in South Africa. The National Health Insurance Act was subsequently published in 2023 (RSA, 2023). This policy will necessitate significant reorganization of the current healthcare system. While these policy changes interact with political dynamics, they are expected to disrupt the current landscape of public health provision as the country moves toward mandated digitalization.

To achieve this goal, the NDoH contracted the Council for Scientific and Industrial Research (CSIR) in July 2013 to develop a Health Patient Registration System (HPRS). This system would standardize patient registration across all health facilities using a unique patient identifier (UPI). The Health Patient Registration Number (HPRN) will help track healthcare facility utilization, support continuity of care, and potentially reduce unnecessary repeat procedures by linking to electronic health records. The HPRS also enables the population of a patient registry and enhances the health sector’s capacity for planning and service delivery. Furthermore, it tracks beneficiaries accessing services at various levels of care.

Although the NDoH could efficiently manage the rapid deployment of hardware and the installation of the HPRS at the facility level, this alone does not ensure correct usage, meaningful impact at the facility level, or the realization of an integrated information system for the NHI. Research has established that the mere availability of technology does not translate to its effective use (Swartz, LeFevre, Perera et al., 2021), and mandated use is rarely successful (Yeung, Taylor, Hui et al., 2012). The technology adoption theory posits that users are more likely to adopt technology if they perceive its value to their practice (Davis, Granić, & Marangunić, 2024). Building on Ajzen’s Theory of Planned Behaviour (Ajzen, 1985; Ritchie, Van den Broucke, & Van Hal, 2021), Davis et al. (2024) et al. argue the decision to use new technologies is influenced by various factors.

However, the practical implications of digitalizing entrenched workflows in primary healthcare settings have not been fully appreciated or mitigated. Introducing technology into established practices is inherently disruptive, with the potential to either enhancing current workflows minimally or significantly alter existing activities and processes (Leadbeater & Wong, 2010). For users who must adapt to new technologies, this shift can be daunting, especially when the perceived advantages or institutional goals of the change are unclear. Moreover, these changes often involve new skill sets and are seen as more time intensive. Reports indicate that technology implementations frequently focus on infrastructure, which represents only a fraction of what is necessary for successful adoption.

For national institutions, the anticipated benefits of such technological implementations are part of a broader effort to fulfil their mandates (Wiklund & Pucciarelli, 2009). The health sector's Negotiated Service Delivery Agreement (NSDA) 2010-2014 acknowledged that, despite significant investments in health ICT and Health Information Systems (HIS), these systems did not meet the requirements to support health system processes. As a result, the healthcare system struggles to produce adequate data for management, monitoring, and evaluation, partly due to a lack of technology regulation and policy frameworks for infrastructure delivery (NDoH, 2010, p. 14). Consequently, there is a significant risk of failure - estimated at around 20–26% - which needs to be addressed among all stakeholders (Shtëmbari, 2017).

To address these challenges, the HPRS was deployed in 700 Primary Health Care (PHC) facilities located in selected NHI Pilot Districts. This provided an opportunity to implement and refine a strategy that eventually became the *Positive Infusion Strategy*, aiming to scale and enhance the National Health System. A national implementation agenda was established to promote the rollout, institutionalization, and adoption of the HPRS. This raised a critical question:

> *How can the strategies, approaches, and experiences gained from the initial implementation inform a formal description of the Positive Infusion Strategy for future deployment?*

The explicit articulation of the Positive Infusion Strategy will be necessary in meeting implementation targets and shaping future practices. Such a structured approach could also foster dialogue on the broader implications and impacts, as well as on the potential for scaling and generalizing the process across various contexts.

7.2 Research Methodology

This study's empirical focus examines various levels of public healthcare facilities, particularly considering the experiences of frontline users of the technology. The aim is to describe the conceptualization, design, and application of the Positive Infusion Strategy, an innovative approach developed to facilitate the adoption and use of the Health Patient Registration System (HPRS) at the Primary Health Care (PHC) level.

The Positive Infusion Strategy set out to institutionalize the HPRS in 1,500 PHC facilities by the first quarter of 2019. Throughout its development, the strategy underwent multiple iterations and emerged as a grassroots health information system implementation process that supports the realization of an integrated information system for the National Health Insurance (NHI). This approach is specifically tailored to address challenges within the South African healthcare context and underpins the HPRS program (Wiklund & Pucciarelli, 2009; NDoH, 2010).

The study employs a case study methodology to understand outcomes by exploring, identifying, and describing the mechanisms driving those outcomes. It uses a process tracing research design, as adapted from Beach and Pedersen (2013) to examine these mechanisms closely. Within the multifaceted public healthcare environment, the study identifies and traces the processes that supported or hindered the implementation of the Positive Infusion Strategy across 700 PHC facilities in selected NHI Pilot Districts.

7.2.1 Case Study Methodology

Case studies have extensively been used in various disciplines but is considered particularly apt for social sciences. The ability to engage with the lived life as presented in complex dimensions and the in-depth multi-faceted understanding it can generate is of particular value (Crowe, Cresswell, Robertson et al., 2011). Lazar, Feng and Hochheiser (2017) identify four goals of case studies as i) exploration, aiming to understand to eventually inform; ii) explanation, that presents understanding; iii) description, that presents a system, process or design; and iv) demonstration, that illustrates a premise.

This study utilises the broad nature of the case study to delineate the bounded context of its concern (Cresswell & Sheikh, 2013). Placing the concern of adoption and institutionalisation with in the complex environment of the Public Healthcare, it not only commits to engage with the lived experiences of individuals in this environment, but is also cognisant of the greater reality in which it exists. As such the lived experiences is framed by certain realities that are present such as policies and national strategies. These outside forces shape and change the individual's reality in ways that are, on the one hand predictable and on the other, disruptive (Lauckner, Paterson, & Krupa, 2012).

Consequently, this case study presents a vehicle to, not only examine the NDoH's policies and strategies, but to interrogate their impact on practice. Within this multi-dimensional reality, the actor's decisions are interpreted through the rational choice theory (Scott, 2000). Elster (1998, p. 13) argues that "the elementary unit of social life is the individual human action. To explain social institutions and social change is to show how they arise as the result of the action and interaction of individuals." This study then contends that the actions and interactions of the individual at the healthcare facility is of fractal importance to the successful operationalisation of the NDoH's policies and strategies. To structure social change is then to structure individual interaction at scale. To describe and articulate such a change at scale would enable predictive anticipation of future change.

7.2.2 Process Tracing Research Design

Beach (2020, p. 700) describes process tracing as "*an in-depth within-case study method for tracing causal mechanisms and how they play out within an actual case*". Process tracing allows researchers to examine how sequences of events unfold within a case and to investigate the underlying causal processes. Bennett (2010, p. 208) similarly defines process tracing as a method that examines diagnostic pieces of evidence within a case to either support or challenge alternative explanatory hypotheses. The method emphasizes identifying the sequences and mechanisms involved in hypothesized causal processes and seeks to determine whether the observed events align with predictions from different explanatory frameworks (Bennett, 2008). The primary goal is to trace causal mechanisms within social science research.

Qualitative data, which is often used in process tracing, refers to non-numerical data that characterizes and describes phenomena, rather than quantifying them (Silverman, 2015). This type of data is typically observed in its natural context, making it suitable for the in-depth analysis that process tracing requires.

As noted in the previous section, process tracing provides a framework for capturing and articulating the conceptualization, design, and implementation of the Positive Infusion Strategy. This strategy facilitated the adoption and use of the Health Patient Registration System (HPRS) at the Primary Health Care (PHC) level (Beach & Pedersen, 2013).

This study follows the approach developed by Beach and Pedersen (2013) in *Process-Tracing Methods: Foundations and Guidelines*, and updated in 2020 by Beach in "Process Tracing Methods", where they outline three distinct types of process tracing: (i) theory testing, which evaluates known processes; (ii) theory building, where new processes are captured and understood; and (iii) explaining outcome process tracing, where the focus is on explaining a specific outcome.

Guided by the study's research aim, this narrative employs the theory-building process tracing method (Beach & Pedersen, 2013, p. 16), which seeks to develop a theory that may be generalized to other interventions in different contexts. Beach and Pedersen (2013) describe theory-building process tracing as involving several interconnected components, each composed of entities such as individuals, organizations, or systems. These entities engage in activities that form part of a causal mechanism, as illustrated in Figure 7-1.

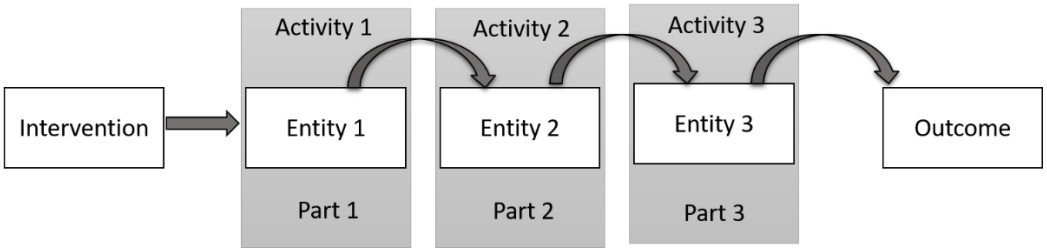

Figure 7-1: A causal mechanism in process tracing. Adapted from Beach and Pedersen (2013)

Beach and Pedersen (2013) conceptualize a mechanism as more than just an empirical event. It represents causal forces or powers that drive an outcome and exists systematically, independent of any particular event. A singular causal mechanism is analysed in detail, including its constituent parts, which may operate on different levels—macro or micro—depending on the scope and focus of the study. This flexibility allows researchers to pitch the study at a level that best fits the phenomenon under investigation.

Beach and Pedersen (2013) emphasize that process tracing is intended to build a *midrange theory*, which describes a causal mechanism that can be generalized beyond a single case to a bounded context. This approach also recognizes the influence of external, or *out-of-case* factors that may shape the observed causal process.

In applying this methodology, Beach and Pedersen (2013) outline five key steps for theory-building process tracing, which have been adapted for this study.

Table 7-1: Steps for theory building process tracing (Beach & Pederson, 2013)

Step	Application to the study
Step 1: Collect evidence	Evidence is compiled through document analysis, drawing from progress reports, evaluation reports, and official presentations from stakeholders. The narrative evidence is presented in Chapters 3 and 4.
Step 2: Operationalize the causal mechanism	Identify observable manifestations of the causal mechanism, based on the narrative in Chapters 3 and 4. Evidence includes both account evidence (e.g., meeting minutes, observed instances, oral accounts) and trace evidence (e.g., official meeting minutes, presentations). As Beach and Pedersen (2013, p. 17) note, "evidence does not always speak for itself," as theory-building involves both deductive and creative elements.
Step 3: Develop a hypothesized causal mechanism	Each part of the mechanism is framed as a hypothesis, building on existing theoretical work, as discussed in Chapter 6.
Step 4: Assess evidence	The evidence is evaluated to determine if it is sufficient to support the hypothesized causal mechanism, with details outlined in Chapter 5.
Step 5: Present the conclusion	Conclusions are presented along with a degree of confidence based on the collected evidence, in Chapter 6.

Figure 7-2 illustrates this theory-building process tracing method, with steps one and two often regarded as iterative, reinforcing each other as the analysis deepens.

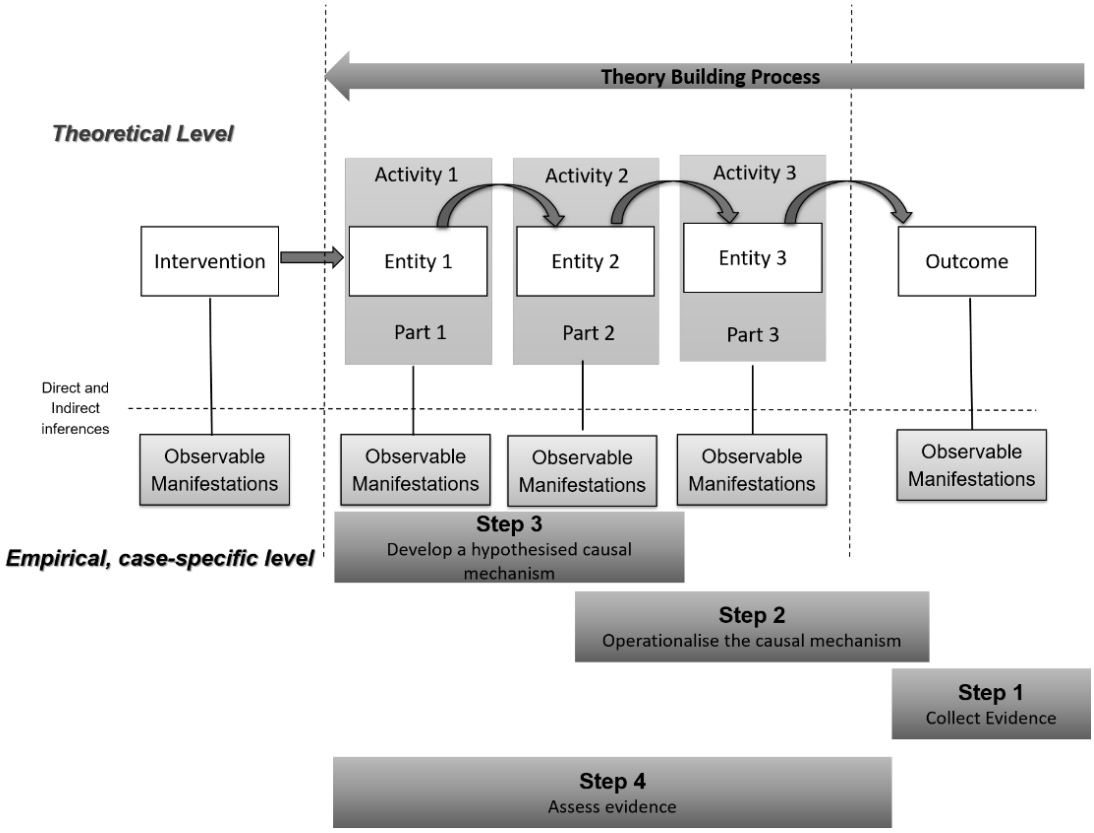

Figure 7-2: Theory-building process tracing. Adapted from Beach and Pedersen (2013)

Theory-building in process tracing involves a creative dimension, drawing on existing theoretical and empirical work. For this study, the theoretical framework incorporates technology adoption theories, particularly the Technology Adoption Model (TAM) (Davis et al., 2024), within the broader context of Universal Healthcare in South Africa. As rational choice theory suggests (Scott, 2000), system utilization is seen as motivated by individual actions framed within national objectives like Universal Healthcare. This acknowledges the multifaceted nature of the phenomena under study.

Furthermore, process tracing studies often integrate multiple individual case studies within a broader framework. As Beach and Pedersen (2013, p. 94) argue, "*internally, each process-tracing study utilizes a mechanistic understanding of causality*" to infer whether the individual parts of the mechanism are present and if they are sufficient to explain a particular outcome. This method is deemed adequate for establishing causal relationships within this study, as it allows for within-case inferences using detailed process tracing. Although cross-case references are limited, they provide contextual insights that directly impact the case.

7.2.3 Causal Mechanisms

Operationalizing a causal mechanism involves identifying observable manifestations supported by evidence. As Collier, Brady and Seawright (2010) suggest, causal process observations refer to insights or data that inform causal inferences. These observations, when validated and contextualized, become evidence. To infer causal links between different parts of a mechanism, it is essential to consider plausible alternative explanations and seek out observable manifestations of the mechanism's operation.

Evidence for this study includes both primary and secondary sources, enabling inferences about the causal mechanism. The assessment of this evidence relies on Bayesian probability logic, which provides a framework for gauging the strength of the evidence and the degree of confidence in the inferred causal process (Chen, Testa, Ansong et al., 2020).

Beach and Pedersen (2013) outline four tests for evaluating evidence based on the principles of certainty and uniqueness: straw-in-the-wind tests, hoop tests, smoking gun tests, and doubly decisive tests (Beach, 2020; Bennett, 2010; Collier, 2011; Van Evera, 1997). These tests form a continuum of evidentiary strength:

- Straw-in-the-wind tests offer low certainty and uniqueness, serving as initial, weaker forms of empirical evidence.
- Hoop tests provide high certainty but low uniqueness, indicating that a hypothesis must pass the test to remain viable.
- Smoking gun tests have high uniqueness but lower certainty, offering strong evidence when passed but not necessarily required for the hypothesis.
- Doubly decisive tests combine high certainty and high uniqueness, offering the strongest validation for causal mechanisms (Beach, 2020; Van Evera, 1997).

As Beach and Pedersen (2013, p. 120), emphasize, empirical material must be critically evaluated before it can be considered evidence for causal inferences. Evidence is not merely raw data; it must be interpreted within the specific context of the case. In this study, evidence is analysed through the hermeneutic cycle, which seeks to understand the relationship between individuals, organizations, and information technology in context (Myers, 2016). This approach involves analysing project documentation, meeting notes, and presentations, supplemented by participant observation and rich descriptions where relevant.

The principles, proposed by Klein and Myers (1999), for hermeneutic interpretive analysis, are put into effect as detailed in Table 7-2.

Table 7-2: Principles for hermeneutic interpretive analysis and its applicability to this study (Klein & Myers, 1999)

Fundamental principles	Explanation (Klein & Myers, 1999)	Applicability to this study
Hermeneutic Circle	Human understanding is derived through iterating between the parts and the whole.	An understanding will be created by using different sources of data.
Contextualisation	Understanding the current situation in the light of what emerged from the past.	The study will highlight the gradual inculcation of technology in people's lives.
Interaction between the researcher and the subjects	Reflects on the construction of data resulting from the interaction between the researcher and participants.	Data will be constructed as the relationship between the researcher and the participants progresses.
Abstraction and generalisation	This entails applying the data collected to theory and practice.	The data collected will be compared to the theoretical understanding.
Dialogical reasoning	Revising the differences arising from the theoretical preconceptions to the data collected.	The researcher will constantly revise the data to account for the differences that arise between the theoretical understanding and practice.
Multiple interpretations	Requires accounting for different interpretations.	Different interpretations will be explored.
Suspicion	Understanding possible *biases* and *systematic distortions* in data collected.	Data will be collected and interpreted with a sensitivity to possible bias.

Having framed the Research Methodology for this chapter, the following section contextualised the case study through a rich description of the complex environments in South African Public Healthcare and the notion of Universal Healthcare in South Africa (NDoH, 2017).

7.3 Contextualising the Case Study

This section is part of Step 1: Gathering Information of the Process tracing operationalisation. It aims to contextualise the study through literature insights to frame the complex environments in South African Public Healthcare and the notion of Universal Healthcare in South Africa (NDoH, 2017).

7.3.1 South African Public Healthcare

In South Africa healthcare services are offered through a three-tier system: public, private and non-government organisations (NGOs) (Jobson, 2015) to a population of nearly 63 million (Statistics SA, 2024). The majority of the population (about 84%) are dependent on public health institutions for healthcare services (NDoH, 2019) whereas the remainder use the private system. In 2022/3, South Africa spent 12.2% of GDP on health care (UNICEF, 2020). The latest budget proposes spending R272 billion on Health in the 2024/25 budget year (SA Reserve Bank, 2024). About 60% of doctors work in the private sector (Ngene, Khaliq, & Moodley, 2023).

Since the dawn of democracy, the National Department of Health (NDoH) has embarked on several initiatives to reform the health system in general and eHealth in particular. The commitment to re-engineering the health system, has been driven by the country's quadruple burden of disease, which has been fuelled by a range of risk factors or challenges including unsafe sex and sexually transmitted infections (Scheibe, Richter, & Vearey, 2016); interpersonal violence and alcohol abuse (Corrigall & Matzopoulos, 2012); poor diets (Padayachee, Chetty, Matse et al., 2013); and maternal and childhood malnutrition (Bamford, 2013; Peer, English, Honikman et al., 2016).

Before the 1980's the health system in South Africa consisted of public health facilities and non-governmental facilities were mission hospitals and occupational health facilities were found largely within the mining industry. The development of the burgeoning private sector has skewed the availability of financial and human resources away from lower income groups and rural areas. Fifteen percent of the population has private medical aid coverage, which accounts for 46% of total health expenditure while 62% of general practitioners and 66% of specialists work in the private sector, increasing the patient load on state health care workers (Coovadia, Jewkes, Barron et al., 2009).

Years of underfunding, mismanagement and neglect has culminated in the degradation of many state health facilities. Systemic health inequalities are found between provinces as well as within metropolitan areas with considerable differences in the provision of health services and resultant mortality and morbidity present (Mayosi & Benatar, 2014).

A priority for the Health Sector is to improve the health status of the entire South African population towards realising the Government's vision of "a long and healthy life for all South Africans". Operationalise this vision, the South African Government has identified four strategic outputs that which health sector must achieve. These are:

- Output 1: Increasing Life Expectancy;
- Output 2: Decreasing Maternal and Child mortality
- Output 3: Combating HIV and AIDS and decreasing the burden of disease from Tuberculosis; and
- Output 4: Strengthening Health System Effectiveness.

The Negotiated Service Delivery Agreement (NSDA) 2010-2014 of the health sector, produced in 2010, observed that: "Although large sums of money have been used to procure health ICT and HIS in South Africa in the past, the ICT and HIS within the Health System are not meeting the requirements to support the business processes of the health system thus rendering the healthcare system incapable of adequately producing data and information for management and for monitoring and evaluating the performance of the national health system. This results from the lack of technology regulations and a lack of policy frameworks for all aspects of infrastructure delivery" (NDoH, 2010).

In terms of Section 74 of the National Health Act, the National Department of Health (NDoH) is responsible for the facilitation and coordination of health Information. The NDoH exercises its coordination and facilitation role through the National Health Information System of South Africa (NHIS/SA) committee.

The District Health Management Information (DHMIS) Policy (2011:9, 17) defines the requirements and expectations from national, provincial, district, sub-district and health establishments and stipulates that the overall ownership of the DHMIS resides with the Director-General of the National Department of Health.

The eHealth Strategy South Africa (NDoH, 2012) provides a road map for achieving a well-functioning national health information system with the patient located in the centre. *"This system will generate comprehensive, reliable, good quality data for patient care, health planning, resource allocation and enhancing management capabilities"*. The strategy also seeks to ensure that the integrated national patient-based information system will be based on agreed-upon scientific standards for interoperability, which improves the efficiency of clinical care, produces the indicators required by management, and facilitates patient mobility. The architecture of this system will further enable an interface with other transversal systems used in health sector. Such a system is also a critical enabling factor for the implementation of National Health Insurance (NHI).

Both the NSDA 2010-2014, and eHealth Strategy 2012-2016 highlights the critical need to coordinate this initiative in a structured systematic manner to foster a culture of integration and not the development of information systems in silos.

The White Paper on National Health Insurance (2017 Section 8.5) views a NHI IS as crucial in enabling :

- Data exchange between the NHI Fund membership database and the accredited and contracted healthcare providers (Par 301).
- Monitoring of the extension of coverage in all population sectors (Par 302).
- Tracking of the health status of the population and production of disease profile data for use in computing capitation allocations (Par 302).
- All the financial and management functions (Par 302).
- Utilisation of healthcare services by those entitled to accreditation to provide NHI service (Par 302).
- Support planning and decision-making around contracting, purchasing and communication strategies (Par 302).
- Quality assurance programmes for healthcare providers (Par 302).

- Production of reports for health facilities and health system management (Par 302).
- Research and documentation to support changes as the healthcare needs of the population change (Par 302).

7.3.2 Universal Healthcare in South Africa

Towards Universal Health Coverage (UHC)(NDoH, 2017), South Africa is in the process of implementing National Health Insurance (NHI). The NHI is aimed at ensuring that: all South Africans irrespective of their socioeconomic status have access to quality health care health services are delivered equitably the population does not pay for accessing health services at the point of use the population has financial risk protection against catastrophic health expenditure. The notion of national health insurance was first documented in 1945 as the Gluckman Commission proposed a fully tax funded National Health Service. After four decades of relatively little movement around this topic, a debate arose in 1980 as government support grew for the privatisation of health services. In 1994 with the dawn of the new South African democracy, the Health Care Finance Committee suggested that private insurers could act as intermediaries for Social Health Insurance. In 2002 the Taylor Committee of Inquiry suggested a mandatory contribution for formal sector employees earning above certain tax thresholds. The implementation of the NHI was publicly initiated by the publication of the NHI Green Paper, in 2011 and proposed that the NHI would be implemented over 14 years in three phases starting in 2012. The NHI White Paper was published by the Department of Health in December 2015 providing stakeholders with an opportunity to present submissions. The NHI White Paper, signed off by Dr Motsoaledi on 28th June 2017, retained much of the NHI White Paper 2015 (version 40) with some amendments and updates based on the current South African Healthcare state of affairs. The NHI Bill was signed into law on the 15th of May 2024 by the President and the NHI Act will be gradually phased in using a "*progressive and programmatic approach based on financial resource availability from 2024 to 2028*"(Government of South Africa, 2024; NHoD, 2024).

The NHI Act(2024, p. 40), in regards to a national Health Information System, states: "*The Fund must contribute to the development and maintenance of the national health information system as contemplated in section 74 of the National Health Act through the Information Platform established in terms of section 40*" and that "*data must be accurate and accessible to the Department and the Fund, or to any other stakeholder legally entitled to such information*." Further to this, the White Paper on National Health Insurance 2017 (Section 8.5)(NDoH, 2017) views a NHI Information System as crucial in enabling :

- Data exchange between the NHI Fund membership database and the accredited and contracted healthcare providers (Par 301);
- Monitoring of the extension of coverage in all population sectors (Par 302);
- Tracking of health status of the population and production of disease profile data for use in computing capitation allocations (Par 302);

- All the financial and management functions (Par 302);
- Utilisation of healthcare services by those entitled accredited to provide NHI service (Par 302);
- Support planning and decision making around contracting, purchasing and communication strategies (Par 302);
- Quality assurance programmes for healthcare providers (Par 302);
- Production of reports for health facilities and health system management (Par 302); and
- Research and documentation to support changes as the healthcare needs of the population change (Par 302).

The need for a population registration system is identified in Ch 18, Par 140 of the Policy Paper (Green Paper) on National Health Insurance in South Africa dated 12 August 2011. The NHI Act refers to the Health Patient Registration System's development as part of phase 1 of the NHI implementation (Government of South Africa, 2024).

The following section offers a narrative of the inception and initial implementation of the Health Patient Registration System (HPRS), capturing a snapshot of its early stages. This overview is not intended to reflect the current state but rather to provide historical context, highlighting the developments that led to the evolution of the Positive Infusion Strategy.

7.3.3 Implementation of the HPRS

This section forms part of Step 1: Gathering Information in the process tracing operationalisation, offering a historical narrative of the initial implementation of the Health Patient Registration System (HPRS). It reflects on a specific moment in time, rather than current developments, to outline the early phases of the system's rollout.

The registration of the population was seen as crucial not only for identifying those eligible to benefit from the National Health Insurance (NHI) but also for to enable the National Department of Health (NDoH) to plan healthcare facilities and services. This planning was designed to support the capitation reimbursement scheme and facilitate tracking of healthcare usage and linkage to electronic health records, ultimately improving service delivery.

In July 2013, the National Department of Health contracted the Council for Scientific and Industrial Research (CSIR) to develop the HPRS. The system aimed to standardize patient registration across all health facilities using the South African Identity Number as a unique identifier. Its purpose was to create a comprehensive patient registry to support healthcare sector planning and improve service delivery. It also tracked beneficiaries accessing services at different levels of care.

At that time, the system had completed version 0.1.3, with capabilities that included:

- Barcode scanning (ID book and driver's license) and biometric reader.
- Patient lookup (demographics, facility linkage, patient file number).
- Generation of patient file numbers.
- Maintenance of patient details.
- Linkage of patients to Primary Health Care (PHC) facilities.
- Recording of visits (date, time, facility, purpose).
- Management information related to health service provision.

The policy context surrounding the publication of the eHealth Normative Standards Framework, along with the development of the HPRS, provided the foundation for the conceptualization and implementation of a broader eHealth interoperability norms and standards program. This program allowed for a reference implementation of an integrated package of eHealth standards at the time.

7.3.4 Implementation Methodology for Rollout and Implementation

7.3.4.1 Programme Description

The 700 Primary Health Care (PHC) facilities located in the NHI Pilot Districts represented, at the time, a unique opportunity to implement and refine the eHealth strategy with the vision of scaling up efforts to improve the National Health System. This snapshot reflects the early objectives of the initiative, which aimed to enhance the patient experience within the healthcare system, particularly by reducing waiting times at healthcare facilities.

The primary goal of this program was to improve patient satisfaction by addressing one of the most significant issues: long waiting times. While various solutions and strategies were available, this project focused on a technological response to the problem. The implementation of an integrated eHealth system, capable of identifying, tracking, and managing patients, was seen as a critical step toward improving patient experiences. Long wait times were recognised as a major contributor to dissatisfaction within the public healthcare system, and it was anticipated that better patient management and more efficient administrative systems would lead to substantial reductions in waiting times.

Additionally, the program aimed to improve the quality of health data and ensure timely access to information, which was essential for effective decision-making. The design of the project took into account the structure of South African health services, which are delivered across three levels of government: national, provincial, and district, with the district health system serving as the vehicle for implementing Primary Health Care.

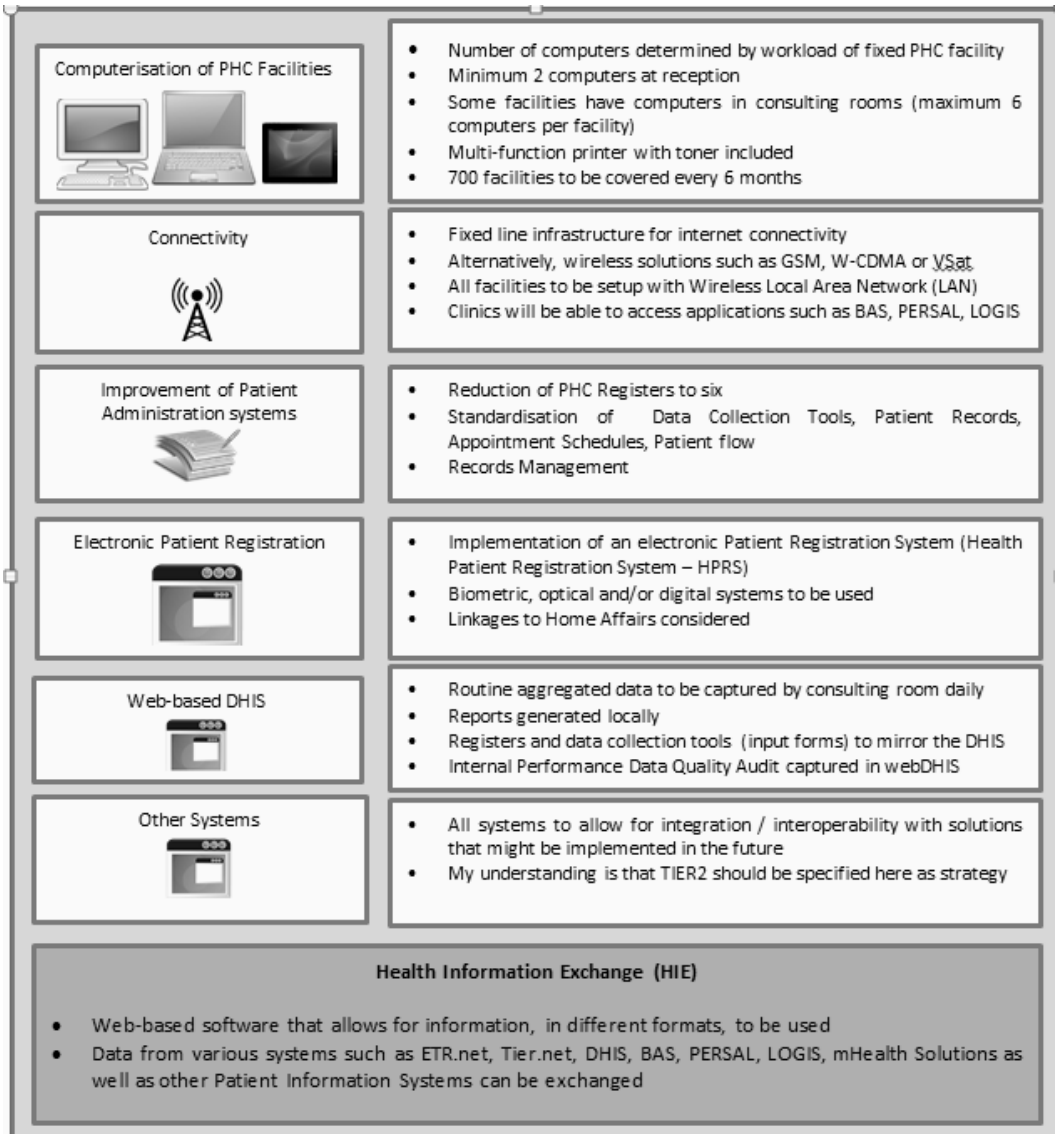

Figure 7-3: Health Information Exchange (NDoH)

In line with the eHealth Strategy of South Africa, and considering the challenges identified at the time, a package of interventions was proposed for roll-out in the 700 PHC facilities within 10 NHI Pilot Districts. These interventions required a carefully sequenced approach: first, deploying the necessary hardware and establishing connectivity; next, providing training on the use of the software; and finally, implementing a change management process to support nurses and clinicians as they transitioned from paper-based systems to electronic systems. The success of the project depended on the optimal use of resources for development, training, and rollout, ensuring alignment with the integrated approach envisioned from the outset.

The successful implementation of this project hinges on a tight sequence of events, namely hardware deployment and establishment of connectivity, training in the use of the software, and

careful implementation of a change management process to ensure that nurses and clinicians are supported in the move from paper-based systems to electronic systems. Optimal usage of all resources for development, training and rollout is in line with the ethos of an integrated approach.

7.4 Implementation Methodology

7.4.1 Beta Implementation

The Beta implementation phase followed an action-learning approach, allowing the team to respond to challenges as they arose rather than adhering to a rigid framework. This phase tested the overall approach, tools, and strategy at 50 Beta Implementation sites, ensuring flexibility and adaptability. Success was made possible through extensive capacity building at the provincial level, which fostered local ownership and accountability.

To guide the project's deployment, the following task teams were established:

- System Integration Task Team: Responsible for developing the packaged deployment strategy, defining minimum training requirements, ensuring technical interoperability, and managing data flow processes, including the interface with the Health Information Management (HIM) system.
- Communications Task Team: Focused on change management strategies, stakeholder engagement, and communication.
- Capacity Building Task Team: Tasked with assessing available resources and developing a comprehensive training program, which included mentoring and support.

The Beta implementation at the 50 sites, situated across 8 provinces, provided a benchmark for the program. These benchmarks are crucial for developing a rapid scale-up strategy for broader implementation. Provincial ownership, coordinated integration, and local capacity building were key drivers of success. Experiences from this phase allowed for adaptation to province-specific needs and challenges.

7.4.2 Key Role Players

The implementation required an integrated approach, uniting all stakeholders under a single management framework. This approach ensured that partners involved in eHealth initiatives in public health facilities worked collaboratively with the National Department of Health (NDoH) as one cohesive unit.

7.4.2.1 National Health Council (NHC)

The NHC was responsible for:

- Making key policy decisions.
- Approving the overall program.
- Approving and monitoring the implementation plan.

7.4.2.2 National Department of Health (NDoH)

The NDoH played a pivotal role in the project's execution, reporting quarterly to the National Health Council. The department's responsibilities included:

- Funding the project.
- Communicating with provincial and district officials via a strategic communication plan.
- Delivering and installing computer hardware and operating systems.
- Managing the project at all levels.
- Monitoring and evaluating progress and outcomes.

7.4.2.3 Council for Scientific and Industrial Research (CSIR)

The CSIR's role focused on:

- Developing and implementing the Health Patient Registration System (HPRS), including biometric and scanner functionality.
- Training, mentoring, and supporting districts and healthcare facilities.
- Facilitating the transfer of skills at provincial and district levels.
- Participating in the development of the Health Information Exchange (HIE).
- Rolling out connectivity solutions in the 50 Beta sites.
-

7.4.2.4 Health Information Systems Program (HISP)

HISP contributed by:

- Upgrading to a web-based District Health Information System (DHIS).
- Implementing the Rapid Internal Performance Data Audit (RIPDA).
- Developing a web-based DHIS Daily Data Capturing (DDC) system.

7.4.2.5 Health Systems Trust (HST)

HST was instrumental in streamlining and standardizing various aspects of patient management, including:

- Reducing the number of Primary Health Care (PHC) data collection registers to six.
- Standardizing patient records, patient flow, and filing systems.
- Implementing standardized reception services.
- Leading the change management strategy.

7.4.2.6 Provincial Departments of Health

Each Provincial Department provided support to district teams and appointed a Provincial Programme Champion, who served as the main contact point for the National Team. This individual was tasked with:

- Troubleshooting issues that could be resolved locally.
- Developing and implementing a scale-up plan for the program in their province.

7.4.2.7 District Management

District Management facilitated and supported program implementation by:

- Ensuring help was available to facilities as needed.
- Implementing asset management protocols.
- Scaling up the training of additional facility staff to ensure sustainability of the system.

7.4.2.8 Facility Managers and Staff

Facilities were visited by the implementation team, along with district and provincial officials, to orient staff on the project and outline the process. To minimize disruption to ongoing services, shorter, more focused presentations were given, with guidance from Facility Managers. One example involved adjusting team visits to start later in the morning, after consulting with a Facility Manager who advised the team to arrive at 10 am to reduce interference with morning services.

The Operational Manager provided guidance on who should be trained and when. The team spent up to five days at each facility, fostering strong relationships with the staff to ensure successful implementation. This collaborative, flexible approach not only facilitated the achievement of project goals but also allowed the team to assist with smaller issues that arose in the clinics.

Building grassroots relationships proved essential to the project's success, creating an environment of cooperation and mutual support that smoothed the transition to the new system.

7.5 Comparison of Beta eHealth Implementation in Vhembe, Thabo Mofutsanyane, and Gert Sibande Districts

The Beta testing phase of the eHealth implementation programme offered valuable insights into the dynamics of implementing a new system across various districts. By February 2015, substantial progress had been made across the three districts of Vhembe, Thabo Mofutsanyane, and Gert Sibande, albeit with differing degrees of success. This section presents a historical reflection, comparing the implementation status during this phase and exploring the factors that shaped these outcomes.

The comparison is organized into two parts:

- An overview of the overall status of programme component deployment across the three districts.
- A detailed comparison of implementation processes using the Programme Maturity Model, focusing on key operational differences between the districts.

7.6 Overall Deployment Status

Table 7-3 reflects the deployment status of hardware, connectivity, patient administration, HPRS, and web-based DHIS across the three districts as of February 28, 2015. The data provides a snapshot of the implementation progress at that time.

Table 7-3: Deployment status of hardware, connectivity, patient administration

Province	Hardware Delivery	Connectivity	Patient Admin	HPRS	Web DHIS
Free State: Thabo Mofutsanyane	Green	Green	Green	Green	Green
Limpopo: Vhembe	Green	Green	Green	Green	Yellow
Mpumalanga: Gert Sibande	Green	Yellow	Red	Red	Red

Key: Green = Completed; Yellow = Challenges Present; Red = No Progress

By the end of February 2015, Thabo Mofutsanyane District in the Free State had fully deployed all five components of the Beta implementation programme. This district's success was largely due to early buy-in from provincial management and strong coordination at the district level.

In contrast, Vhembe District in Limpopo had successfully implemented four of the five components. The deployment of the Web DHIS was delayed due to capacity constraints within the province, though additional personnel were appointed, and follow-up training resolved these issues by March 2015.

The Gert Sibande District in Mpumalanga, however, encountered significant challenges. Although hardware had been delivered, the asset transfer process was incomplete, posing risks of theft. Furthermore, internet connectivity issues and poor contract management with the service provider prevented progress, and by the end of March 2015, none of the five components had been fully implemented. These challenges were escalated for resolution.

7.6.1 Comparison of Implementation Processes

A detailed comparison of the implementation processes across the three districts highlights the differences in approach and execution during the Beta testing phase. The analysis focuses on five key areas:

Table 7-4: Implementation Processes

Province/District	Free State: Thabo Mofutsanyane	Limpopo: Vhembe	Mpumalanga: Gert Sibande
Provincial Introductory Meeting	Provincial managers involved from the outset. Meeting approved by Provincial Head of Department. Attended by senior managers from Health Information, IT, and CFO.	Limpopo was the third province introduced. Active engagement by Head of Department, with all communications channeled through the Vhembe NHI Task Team.	No provincial meeting held. Province opted to attend the District Introductory Meeting instead.
District Introductory Meeting	Attended by 32 District Health Management Team members. 5 Beta sites	Attended by the District NHI Task Team and provincial managers.	Attended by District Management, Provincial IT Manager, and NHI

Province/District	Free State: Thabo Mofutsanyane	Limpopo: Vhembe	Mpumalanga: Gert Sibande
	selected, with an agreement to expand to two additional PHC facilities.	Programme identified as a priority, with support pledged for training and resources.	Coordinator. District IT Manager selected as communication champion.
Site Readiness and IT Preparation	Site readiness and integration completed. Hardware delivered, and assets transferred to provincial and district registers by March 2015.	Site readiness conducted in collaboration with provincial IT staff. Patient flow and administration reform implemented alongside IT setup.	Connectivity issues and delays in asset management caused setbacks. Internet problems persisted, and no hardware transfers were completed by March 2015.
Implementation of HPRS & Web DHIS	All 5 Beta facilities registered 44,196 patients by March 31, 2015. Routine health data captured daily, reducing data reporting time from 30 days to 24 hours.	5 Beta facilities registered 39,533 patients by March 31, 2015. Routine health data was captured daily, significantly improving data reporting turnaround.	No HPRS or Web DHIS implementation due to unresolved infrastructure challenges.
Training and Capacity Building	6 staff members trained per facility. Facility-level buy-in was strong, and training sessions were well coordinated by the provincial champion/s.	6 staff members trained per facility. Training organized and delivered with collaboration between provincial and district IT staff.	No training conducted due to incomplete implementation and unresolved issues.
Impact	Visible improvements in waiting times and congestion, though full impact requires formal evaluation.	Similar improvements in waiting times and congestion, though full impact needs further evaluation.	No visible changes due to lack of implementation.

This comparison sheds light on the factors that influenced the successful implementation of the programme in the Free State and Limpopo provinces, as well as the challenges that stalled progress in Mpumalanga.

7.6.2 Identification of Best Practices and Weaknesses Impacting Implementation

This section explores the best practices that contributed to successful implementation during the Beta phase, as well as the weaknesses that hindered progress in some districts. It offers a historical reflection on the lessons learned from the pilot programme.

7.6.2.1 Common Themes from Provincial and District Management Engagement

One of the most notable successes identified was the establishment of dedicated district implementation teams, supported by provincial leadership. This approach was particularly

effective in Vhembe District, where the programme gained momentum and expanded beyond the original Beta facilities.

However, communication issues were a significant weakness in Mpumalanga's Gert Sibande District, where 82% of the provincial managers were unaware of the programme during the introductory meeting. This lack of communication between provincial and district levels was a primary cause for the delay in implementation.

- *Facility-Level operational assessments:*

Facility visits provided a closer look at the operational realities of the Beta implementation phase. During these visits, discussions with facility managers and staff revealed both the positive impacts and challenges faced by healthcare professionals.

- *Key successes included:*
    - Reduced administrative burden, allowing staff to spend more time with patients.
    - Improved patient flow, which reduced wait times and congestion.

7.6.2.2 Common Themes Identified at Facility-Level Assessments

Implementers' Perspectives

Initially, many healthcare workers were sceptical about the programme due to concerns about their ability to use electronic systems. However, as implementation progressed, these concerns were alleviated. Reduced administrative tasks were cited as a major benefit, allowing staff to focus more on patient care.

Training and Mentorship

The *handholding* and onsite mentorship approach provided by the National Helpdesk was essential for ensuring staff felt supported throughout the implementation process. However, this intensive level of support was time-consuming, and concerns were raised about the sustainability of this approach during the national roll-out.

7.6.2.3 Observations and Analysis from the Perspective of Health System Users

Patients in the Beta facilities reported shorter waiting times and a more streamlined experience. These observations were supported by the Health Systems Trust’s waiting time assessment, which compared pre- and post-implementation data across the facilities.

7.6.3 Way Forward

7.6.3.1 Political Context

The success of the Beta phase secured the support of the National Health Council (NHC), which was crucial for scaling the eHealth programme across South Africa. The political backing ensured that the necessary resources and oversight would be in place to expand the programme to 3,500 PHC facilities nationwide.

7.6.3.2 Institutional Arrangements and Scale-Up

The lessons learned during the Beta phase demonstrated the importance of involving provincial IT teams early in the implementation process. Provincial ownership is essential for ensuring the sustainability of the programme, particularly regarding the procurement of hardware and management of connectivity.

In summary, the Beta Implementation phase offered valuable lessons on the complexities of introducing systemic changes in the health sector. The success of the programme depended heavily on provincial leadership, communication, and local capacity building. As the programme moves forward into the national roll-out phase, these principles will continue to guide efforts to ensure that the eHealth programme contributes to improved healthcare service delivery across South Africa.

7.6.4 Process Extraction

This section presents:

- Step 2: Operationalise the causal mechanism.
- Step 3: Develop a hypothesised causal mechanism.
- Step 4: Assess evidence, in the operationalisation of the Process tracing Research Design.

As such each subsection presents an observable manifestation extracted from the narrative, experiences and learning (Step2) (Beach & Pedersen, 2013; Bennett, 2008; Pedersen & Beach, 2016). This is described and framed as a hypothesis (Step 3) for which evidence (Step 4) is supplied and evaluated. References to evidence includes primary and secondary documentations, observations and field notes.

In process tracing, observable manifestations refer to the concrete events, decisions, or actions that emerge from the real-world execution of a project or intervention. These manifestations are derived from the narrative accounts and empirical evidence gathered during the implementation phase. The goal of analysing these manifestations is to identify how specific processes play out in real time, allowing researchers to trace causal mechanisms that explain outcomes. By doing so, it becomes possible to understand whether certain hypotheses about a programme's success or failure hold true.

Each manifestation is assessed by operationalizing it into a hypothesis (a testable statement about how the manifestation leads to the desired outcome). Evidence supporting these manifestations is then extracted from field reports, observations, and documentation. The type of evidence varies in certainty and uniqueness, and it is critical to determine whether it supports or undermines the causal mechanism.

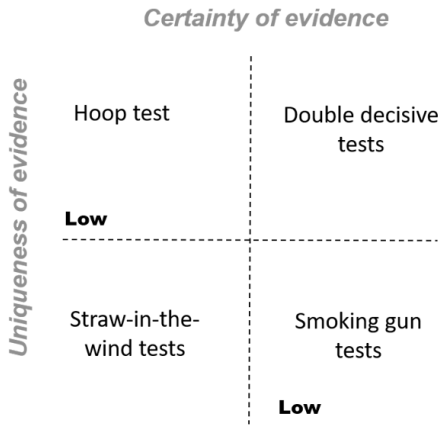

Figure 7-4: The Process Tracing Evidence Test Matrix

This evaluation involves assigning the hypothesis to one of four categories of tests based on the Process Tracing Evidence Test Matrix (shown above):

- Hoop Test: This test provides high certainty but low uniqueness. If a piece of evidence fails the Hoop Test, the hypothesis is seriously weakened or rejected.
- Straw-in-the-Wind Test: This test provides low certainty and low uniqueness. It offers weaker support but may suggest whether a causal relationship could be present.
- Smoking Gun Test: This test provides high uniqueness but low certainty. Passing a Smoking Gun Test strongly supports the hypothesis, but failure does not necessarily undermine it.
- Doubly Decisive Test: This test provides both high certainty and high uniqueness. Evidence passing this test strongly confirms a hypothesis and usually rules out alternatives.

Each type of evidence gathered from the narrative has different implications for understanding the programme's outcomes:

- High-certainty evidence (such as stakeholder involvement or the proper deployment of hardware) indicates that certain processes are necessary for the success of the implementation.
- High-uniqueness evidence (such as real-time data accessibility and trained staff) suggests that these factors are unique determinants of success; without them, the programme is highly likely to fail.

Through this method, the process tracing approach can help validate or make explicit the causal mechanisms at work in the implementation of the Beta eHealth Programme, ensuring that the lessons learned are based on rigorous empirical evaluation.

With this framework in mind, key observable manifestations from the Beta eHealth implementation are presented, starting with Stakeholder Engagement. Each manifestation is framed as a hypothesis, supported by evidence, and evaluated using the Process Tracing Matrix to determine its role in the overall success or challenges encountered during the programme's implementation.

7.6.4.1 *Stakeholder Engagement*

During the Beta phase, stakeholder engagement was pivotal across all levels of the health system. Effective engagement ensured buy-in from key officials at the provincial, district, and facility levels. This collaboration was essential for aligning objectives and securing the necessary resources for smooth programme implementation.

- *Hypothesis H1:*

Early and comprehensive stakeholder engagement across all levels of the health system is essential for the successful implementation of integrated eHealth programmes.

- Evidence:
    - In Thabo Mofutsanyane District, the early involvement of provincial managers, including those from Health Information, IT, and the CFO's office, led to a well-coordinated deployment of the programme, with fewer implementation delays.
    - In Gert Sibande District, inadequate early engagement led to confusion, as 82% of district managers were unaware of the programme during initial meetings, causing significant delays.
    - Sources: Meeting minutes, stakeholder engagement reports, district feedback.
- Test Type: Hoop Test
    - High certainty: Stakeholder engagement is a critical requirement. Without it, successful implementation is unlikely, as seen in Gert Sibande where lack of engagement is directly correlated with failure.
    - Low uniqueness: While stakeholder engagement is essential, other factors such as IT infrastructure, training, and workflow optimization also play crucial roles. Thus, engagement alone does not uniquely guarantee success.

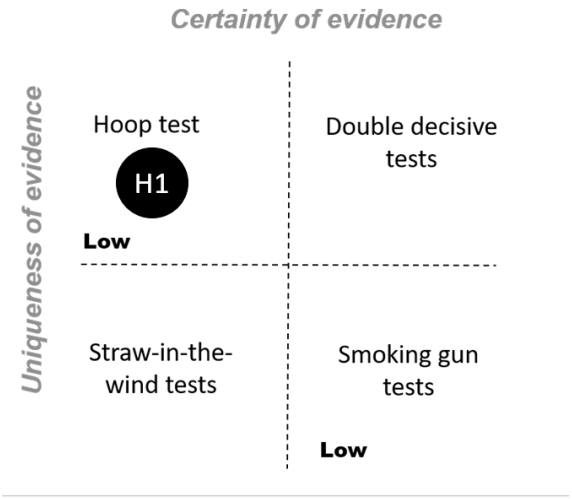

Figure 7-5: Hypothesis H1

7.6.4.2 Deployment of IT Hardware Support

Narrative:
The coordination of IT hardware deployment between provincial and district IT departments was critical in ensuring that the hardware arrived on time and was functional. Proper coordination allowed for timely technical support and smooth hardware integration into the facility environment.

- *Hypothesis H2:*

Deployment of IT hardware must be coordinated with provincial and district IT departments to ensure timely delivery and technical support.

- Evidence:
    - In Vhembe, strong coordination between provincial and district IT teams led to smooth hardware delivery and successful integration into facility workflows. The assets were transferred by March 2015, enabling early use of the systems.
    - In Gert Sibande, delays in hardware transfer and connectivity issues stemmed from poor coordination, resulting in incomplete implementation by the end of the Beta phase.
    - Sources: IT deployment reports, asset transfer records, feedback from IT managers.

- Test Type: Straw-in-the-Wind Test
    - Low certainty: Coordination of IT hardware is important but not sufficient on its own to ensure success. In Gert Sibande, poor coordination was a significant factor, but other challenges like internet connectivity also played a role in the programme's failure.
    - Low uniqueness: While necessary, coordination does not guarantee success, as other elements (e.g., staff training) are equally critical.

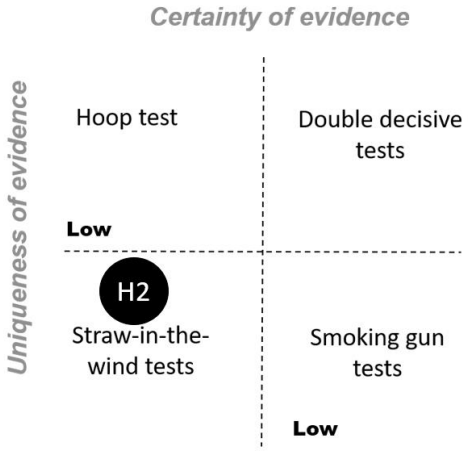

Figure 7-6: Hypothesis H2

7.6.4.3 *Site Preparation, Hardware Integration and Phased Connectivity*

Narrative:
Successful implementation required careful site preparation before integrating the IT systems. This included optimizing patient administration workflows and ensuring that facility environments could handle new systems. Failure to prepare the sites properly would hinder staff training and render the systems ineffective.

- *Hypothesis H3**:***

Before hardware integration and training, site preparation, including the overhaul of patient administration workflows, is essential for ensuring readiness and optimizing facility operations.

- Evidence:
    - In Thabo Mofutsanyane, patient administration workflows were revised and streamlined before hardware integration, leading to more effective training and smoother overall system functionality.
    - In Gert Sibande, poor site preparation resulted in confusion and delays during training, as patient administration systems were not ready for the transition to

eHealth systems.

- Sources: Site readiness assessments, patient administration workflow reviews, training feedback from facilities.

- Test Type: Smoking Gun Test
  - High uniqueness: Proper site preparation is critical. Without it, even with good hardware and trained staff, the system may fail, as seen in Gert Sibande where training failed to take hold due to insufficient groundwork.
  - Low certainty: However, site preparation alone is not enough to ensure success, as other issues (e.g., technical support, training quality) can still impede implementation.

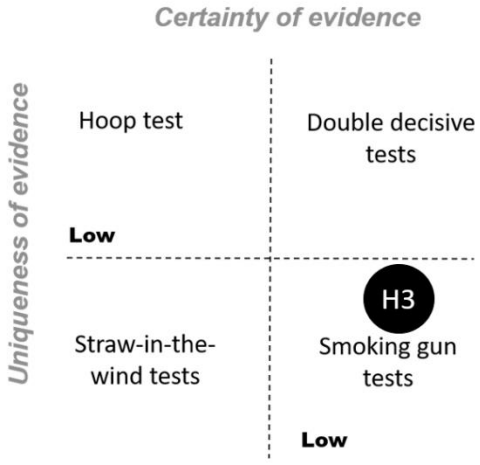

Figure 7-7: Hypothesis H3

7.6.4.4 Implementation of Health Patient Registration System (HPRS) and Web DHIS

Narrative:
The HPRS and Web DHIS implementation dramatically improved patient file retrieval and staff efficiency. However, for these systems to work, facility staff needed to be fully on board with the concept before the training phase began. This reduced resistance and allowed for smoother capacity building.

- ***Hypothesis H4:***

Successful implementation of the HPRS and Web DHIS requires that staff buy into the concept before training begins, ensuring reduced resistance and smoother capacity building.

- Evidence:
    - In Thabo Mofutsanyane, early orientation with facility staff ensured buy-in, which led to more effective training and a faster, smoother implementation of the HPRS system. Staff resistance was minimal, and system adoption was quick.
    - In Gert Sibande, where staff were not adequately prepared or engaged before training, resistance slowed the system's integration, and training sessions faced significant obstacles.
    - Sources: Training logs, facility feedback, patient administration records.
- Test Type: Hoop Test
    - High certainty: Staff buy-in is essential for training and implementation success. In cases where buy-in was missing (as in Gert Sibande), the system faced significant implementation delays.
    - Low uniqueness: However, staff buy-in alone does not guarantee success, as other technical and logistical challenges (e.g., connectivity, hardware) could still disrupt the implementation.

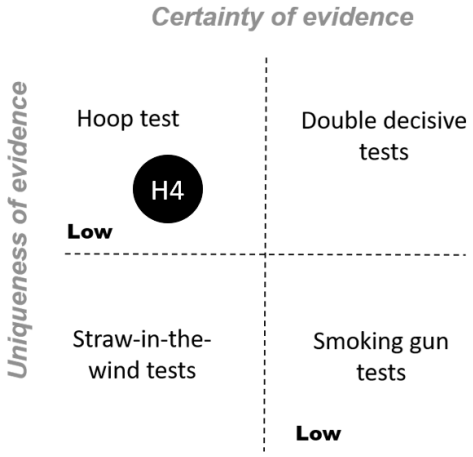

Figure 7-8: Hypothesis H4

7.6.4.5 Web Reporting and Online Capture

Narrative:
The introduction of Web DHIS and real-time online data capture was a game-changer for facilities. By centralizing routine data, facilities could access real-time information, improving decision-making and reducing reporting delays. This system relied on both effective staff training and stable internet connectivity.

- *Hypothesis H5:*

Effective use of web reporting and online capture in healthcare facilities requires real-time data accessibility and trained staff to handle new processes.

- Evidence:
    - Vhembe demonstrated that real-time data capture significantly reduced the time between data collection and reporting, leading to more accurate and efficient health service management.
    - In Gert Sibande, the lack of reliable internet connectivity and insufficient staff training severely limited the use of web reporting systems, delaying the benefits of real-time data access.
    - Sources: Web DHIS data, connectivity reports, real-time data capture assessments.
- Test Type: Doubly Decisive Test
    - High certainty: Real-time data accessibility and trained staff are both necessary for the system to function. Without them, the programme cannot achieve its intended benefits.
    - High uniqueness: These two factors are also unique in determining the programme's success. No other factors can replace real-time data access or the need for trained staff. Without either, the entire system fails, as seen in Gert Sibande.

The process tracing analysis and the accompanying evidence highlight key mechanisms that were either present or absent in the Beta implementation phase of the eHealth programme. Each hypothesis is evaluated based on the certainty and uniqueness of the evidence, offering a clear picture of which factors were most critical to success. This detailed evaluation will guide future implementations, ensuring that lessons learned during the Beta phase can inform more effective strategies moving forward.

7.7 Positive Infusion Strategy

The Positive Infusion Strategy was conceptualised and refined during the Beta phase of the Health Patient Registration System (HPRS) implementation and provided a structured, phased approach for the roll-out of digital health technologies in South Africa. This strategy was designed to ensure local ownership, accountability, and sustainability by aligning key components such as hardware deployment, staff training, and stakeholder engagement across all levels of healthcare. The strategic implementation progressed in four key phases, ensuring a controlled, stepwise expansion from Beta testing to national-scale deployment, outlined below.

7.7.1 Overview of the Positive Infusion Strategy

The Positive Infusion Strategy unfolded in four distinct phases, each building on the previous one to address both technical and organizational challenges while scaling up the HPRS from the initial 50 Beta sites to a full national roll-out across 1,400 facilities. The systematic expansion allowed for continuous feedback, learning, and refinement of the system.

7.7.1.1 *Design and Development (Phase 1)*

- This phase was centred on the design and development of the HPRS software, ensuring that it could be adapted to the diverse needs of various healthcare facilities across South Africa.
- Version 0.2 of the HPRS software was created and underwent Alpha testing to confirm its functionality and alignment with the operational realities of healthcare providers.
- This stage laid the foundation for the Beta testing phase, with a focus on designing a system that could scale while addressing the needs of users at the facility level.

7.7.1.2 *Beta Testing and Software Enhancements (Phase 2)*

- The second phase saw the HPRS undergo Beta testing at 50 selected sites to evaluate its feasibility and functionality in real-world healthcare environments.
- The Beta phase was critical in allowing the project team to identify software bugs, inefficiencies, and the specific needs of healthcare facilities.
- Feedback from Beta sites was incorporated into the system, leading to software enhancements aimed at improving usability and addressing technical challenges before the full-scale roll-out.
- The Beta testing also helped to establish local support teams and build initial capacity at the facility level.

7.7.1.3 *Further Development, Support, and National Expansion (Phase 3)*

- After successfully completing the Beta phase, the HPRS entered a development and support phase aimed at scaling the system across 650 additional facilities.
- This phase focused on integrating the lessons learned from the Beta phase, enhancing the system's capabilities, and ensuring comprehensive support mechanisms were in place.
- Training and mentorship were expanded, ensuring that healthcare staff were equipped to handle the new technology. Facilities received ongoing support through provincial and national helpdesks.
- Stakeholder engagement was key during this phase, with regular communication

between local facility managers, provincial health departments, and national teams to ensure smooth implementation.

7.7.1.4 Full Implementation and National Scale-Up (Phase 4)

- The final phase marked the full national roll-out of the HPRS across 1,400 facilities, supported by the establishment of a dedicated Programme Office to oversee the process.
- This phase ensured that all facilities had the necessary infrastructure, staff training, and ongoing support for the successful use of the HPRS.
- Key services were also introduced during this phase, including the issuance of National Health Insurance (NHI) cards, appointment scheduling systems, and label printing, further streamlining patient care and administrative processes.
- The focus during this phase was on scaling up, with an emphasis on sustainability, long-term system support, and ensuring that healthcare workers could fully utilize the system to improve service delivery.

7.7.2 Narrative Integration of the Positive Infusion Strategy

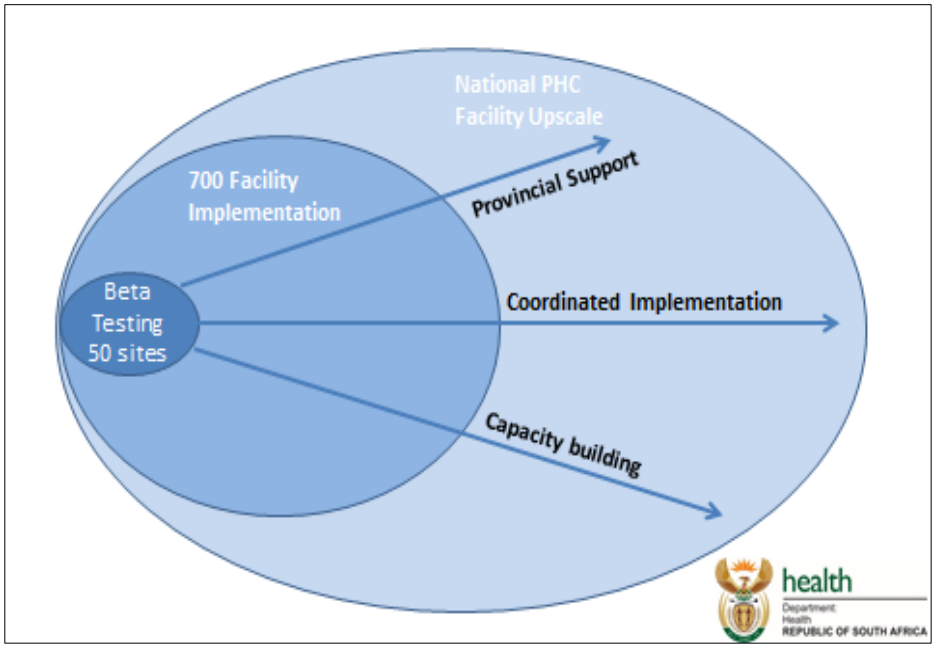

Figure 7-9: NHI 700 Facility Positive Infusion Strategy (NDoH)

The Positive Infusion Strategy followed a methodical, phased approach to the scaling of the HPRS across South Africa. The phased nature of the implementation allowed for real-time learning, with each phase providing crucial insights that shaped the system for the next stage. .

This incremental approach ensured that foundational aspects—such as infrastructure, local capacity building, and stakeholder engagement—were in place before broader deployment. It also allowed for the adaptation of the system to the diverse healthcare environments across the country, ensuring that the system would be flexible and responsive to on-the-ground realities.

7.7.3 Key Success Factors in the Positive Infusion Strategy

7.7.3.1 Local Ownership and Accountability

- A key feature of the strategy was the early and consistent engagement of local stakeholders, from provincial health departments to facility managers.
- This approach helped build a sense of local ownership and accountability at all levels, ensuring that stakeholders were invested in the system's success and empowered to troubleshoot issues as they arose.

7.7.3.2 Phased and Structured Approach

- By phasing the implementation—starting with 50 Beta sites and gradually scaling up to 1,400 facilities—the strategy allowed for continuous learning and adjustments at every stage.
- This phased approach reduced the risks typically associated with large-scale technology rollouts, ensuring that any issues encountered could be resolved before the next phase.

7.7.3.3 Training and Support

- A robust training programme accompanied each phase of the system's implementation, ensuring that healthcare workers at all levels were equipped with the skills they needed to use the HPRS effectively.
- The train-the-trainer model ensured that knowledge could be passed down to new staff, sustaining capacity at the local level.
- The creation of provincial and national helpdesks further ensured that technical and operational challenges could be quickly addressed, providing ongoing support.

7.7.3.4 Flexibility and Responsiveness

- One of the key strengths of the Positive Infusion Strategy was its flexibility. As the system was tested and deployed, lessons learned during each phase were used to adjust the approach, ensuring that the HPRS could meet the specific needs of each facility.

- For example, where patient flow and administrative processes needed to be overhauled before full system integration, these areas were addressed before moving forward with training and system implementation.

7.8 Overview of the Study

The chapter aimed to describe the conceptualisation, design, and application of the Positive Infusion Strategy, which enabled the utilisation and uptake of the Health Patient Registration System (HPRS) at the Primary Health Care (PHC) level. This strategy aligns with the government's broader vision of "a long and healthy life for all South Africans" and the National Department of Health's (NDoH) mandate to facilitate and coordinate health information systems.

The theory-building process tracing methodology (Beach & Pedersen, 2013; Engel, Pedersen, Johansen et al., 2022) was applied to articulate hypotheses that frame the causal mechanisms underlying the deployment of the Positive Infusion Strategy. These processes are summarised in the following table.

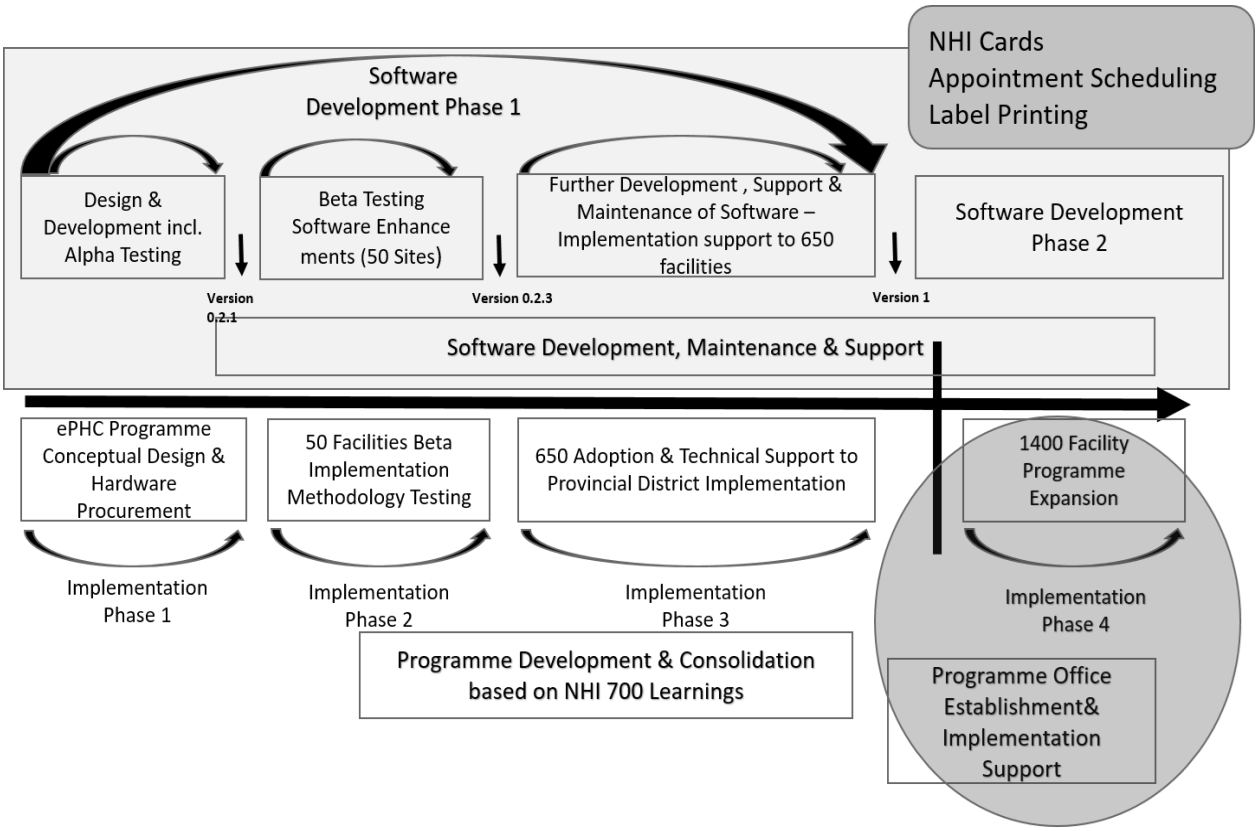

Figure 7-10: Theory Building Process Tracing Applied in this Study

Table 7-5: Summary of Theory Building Process Tracing Applied in this Study

Step	Description
Step 1	Collect evidence through document analysis, progress reports, and official presentations.
Step 2	Operationalise the causal mechanism by identifying specific observable manifestations.
Step 3	Develop a hypothesised causal mechanism based on identified manifestations.
Step 4	Assess evidence to gauge the strength of each causal hypothesis.
Step 5	Present a conclusion and express a degree of confidence based on the evidence.

7.9 Reflection on Key Findings

The research question guiding this study was:

How can the strategies, approaches, and experiences gained in the initial implementations inform a formal hypothesis of the Positive Infusion Strategy for future deployment?

Through the research, five key causal mechanisms were identified and framed as hypotheses:

- **H1**: Early stakeholder engagement across the whole spectrum of stakeholders is essential.
- **H2**: Coordinated deployment of IT hardware with Provincial and District IT departments is crucial.
- **H3**: Site readiness and patient administration optimisation are essential for successful training and system integration.
- **H4**: Staff buy-in and proper orientation reduce resistance to change.
- **H5**: Real-time data access and well-trained staff are critical for the success of web-based data capture.

These findings are evaluated using the Process Tracing Evidence Test Matrix, which provides an understanding of the confidence and uniqueness of each hypothesis.

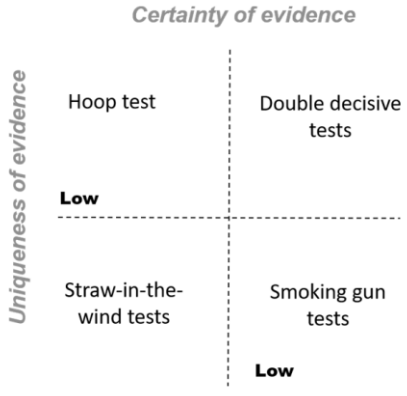

Figure 7-11: Degree of Confidence in Findings

The matrix representation highlights the level of certainty and uniqueness for each hypothesis, aiding in determining the strength of each causal mechanism. The following practical principles for implementation are derived from these findings:

- Engage Leaders Across All Levels: Stakeholder engagement must occur from the National Health Council down to facility level.
- Agree on Timelines with Local Stakeholders: Implementation schedules must be coordinated with provincial, district, and facility staff to ensure readiness.
- Adaptability: Flexibility is key to success—rigidity will hinder progress.
- Supportive Leadership: Implementers must take guidance from ground-level managers, ensuring staff feel supported and involved.

7.9.1 Formal Hypothesis of the Positive Infusion Strategy

From these findings, a Formal Hypothesis for the Positive Infusion Strategy is presented:

Hstudy: The Positive Infusion Strategy argues that if a tight sequence of hardware delivery, installation, training, and initialization, followed by local district monitoring of system usage, is implemented, then local ownership, accountability, and sustainability of the programme are more likely.

This hypothesis encapsulates the lessons learned during the Beta Implementation phase, ensuring that the strategies used can inform future rollouts. The case study demonstrated that buy-in from grassroots officials is imperative for success, making this a central tenet of the strategy.

7.9.2 Significance and Contribution of the Research

The findings of this study offer key contributions to future eHealth implementations:

- Guidance for Rollout Support: Providing clear strategies for ensuring accountability and sustainability.
- Exploratory Insights: Offering new perspectives on the roll-out and uptake of healthcare technology.
- Understanding Digital Health: Expanding the understanding of both the benefits and challenges of electronic health systems.

7.9.3 Limitations of the Study

Following Patton (2004), it is essential to be transparent about the study's limitations:

- Reflective Nature: The study relies heavily on available primary and secondary data, which

introduces the potential for researcher bias.

- Context-Specific Findings: The findings are limited to the specific context in which the study was conducted, affecting the generalisability of the results.

7.9.4 Possible Future Research

Future research could explore predictive studies on the long-term impact of health information systems, policy studies to refine health strategies, and further investigation into process optimisation for healthcare rollouts.

7.9.5 Implications of the Study

The study has significant implications for policy development, particularly regarding the governance and implementation of health information systems. The lessons from this research can inform national health policies aimed at improving the efficiency and effectiveness of healthcare services.

7.10 Concluding Remarks

The Positive Infusion Strategy demonstrated that a well-structured and phased approach to eHealth system implementation can lead to successful, sustainable outcomes when local stakeholders are involved, and flexibility is maintained. The findings provide a roadmap for future health information system rollouts, ensuring that local ownership and sustainability are prioritized in the process.

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Chapter 8: Master Health Facility List Training as an Educational Tool to Reduce the Number of Organisational-Based Support Tickets

Maremi, K.J.[1], Thulare, T.[1] and Nunu, V.[1]

[1]Next Generations Enterprises and Institutions Cluster (NGEI), Council for Scientific and Industrial Research (CSIR)

Purpose: *This chapter explores the necessity of Master Health Facility List (MHFL) training to educate users who joined the system before the introduction of the nomination form. These users face issues associating themselves with their organisations within the MHFL system. The chapter addresses this gap by proposing targeted onboarding training designed to introduce the nomination form to these users and resolve organisational association problems, ultimately reducing MHFL support tickets in South Africa.*

Study design/methodology/approach: *An exploratory qualitative approach was used, adopting a phenomenology design to understand how and why users experience difficulties with the nomination form. The study focuses on the lived experiences of previous MHFL users, providing a comprehensive account of these challenges and their potential solutions through training.*

Findings: *The findings indicated that targeted MHFL training effectively resolves organisational association issues linked to the nomination form. Additionally, the training improves users' technical skills, enhances their engagement with the system, and reduces the number of support tickets logged.*

Originality/value: *This research emphasises the importance of building technical skills in digital health and a capable workforce. This study emphasises the importance of building digital health skills and a capable workforce. The proposed training improves the functionality of the MHFL system, leading to more accurate data management, higher data quality, and better reporting outcomes.*

Keywords: *Master Health Facility List (MHFL), Users of MHFL, South Africa, Digital Health skills, Organisation Association problems, Support Tickets*

8.1 Introduction and Background

In today's healthcare landscape, integrating new technologies is critical for enhancing training systems and equipping healthcare professionals with the digital skills to navigate complex systems.

Information and Communication Technology (ICT) has become a foundational tool in healthcare education, allowing health workers to become proficient users of systems like the Master Health Facility List (MHFL). Information and communication technology (ICT) for training improves access to learning materials and helps participants acquire the practical and technical skills necessary for effective system use, as demonstrated in online training programs in various healthcare settings (Gayed et al., 2019). The MHFL is a central health information system (HIS) in South Africa designed to manage nationwide health facility data. The MHFL is the complete, authoritative listing of the healthcare facilities in South Africa (NDoH, 2023). It is the main source from which other national facility listings are compiled. By maintaining accurate and up-to-date facility information, the MHFL supports better decision-making and resource allocation (NDoH, 2021). The MHFL is a comprehensive database that aids in tracking facility locations, services provided, and operational statuses, which are crucial for health management and planning (WHO, 2019). However, challenges have emerged with users who joined the system before introducing the nomination form, a tool designed to link users to their respective organisations within the system. These early users often struggle to associate themselves with their organisations, leading to an influx of support tickets and burdening the system's support infrastructure. This challenge is not unique to the MHFL; health information systems (HIS) often face similar difficulties during implementation phases when training gaps exist, affecting the system's overall efficiency (Jeyakumar et al., 2021).

To address these challenges, targeted training for early MHFL users is essential. Such training would focus specifically on the nomination form to reduce organizational association errors and minimize support tickets. As shown in other digital systems, effective user training can significantly improve system use, reduce errors, and decrease reliance on support services (Alcivar & Abad, 2016). By equipping users with the knowledge needed to navigate updates to the MHFL, the proposed training can enhance the system's functionality and contribute to a more streamlined digital health infrastructure in South Africa. Therefore, *the chapter aims* to demonstrate the importance of MHFL training in educating users who joined the system before the introduction of the nomination form. This training is essential to address the organizational association issues these users face and to reduce the volume of MHFL-related support tickets.

8.2 Alignment with South African Digital Health Strategy

The World Health Organisation (WHO, 2021) defines digital health as using ICT to enhance the flow and utilisation of information in the health sector, supporting healthcare service delivery and management. As healthcare systems face growing demands, the management and structure of health services must adapt, incorporating digital solutions that enable prompt and accurate decision-making (WHO, 2021).

The South African Digital Health Strategy is underpinned by five key strategic principles namely (NDoH, 2019):

- Person-centred.
- Expanded access to service.
- Innovation for sustainable impact.
- Digital health workforce for economic development.
- Whole-of-government approach.

In line with the National Department of Health's goal of a long and healthy life for all South Africans, the strategy outlines a vision of better health for all South Africans enabled by digital health, as digital health is anticipated to play a significant role in driving the transformation of the health system. This strategy prioritises people to meet the needs of those requiring medical attention, those who can be helped to lead healthy lives, healthcare professionals who offer a wide range of medical services, and managers who must make crucial choices to improve the health system to deliver services (NDoH, 2019:p6) effectively. A key challenge identified in the strategy is the shortage of human resources, particularly in the digital health sector. To this end, one of the strategic interventions to address this is the development of a skilled and qualified digital health workforce capable of supporting and utilising advanced digital technology. The MHFL training contributes directly to this goal in the digital skills of both new and existing MHFL users. By providing targeted training, the MHFL empowers users to engage with the system effectively, ensuring accurate data management and reducing operational inefficiencies, such as the high volume of organizational-based support tickets.

Therefore, this chapter aligns with the Digital Health Strategy by demonstrating the necessity of MHFL training for previous users, focusing on improving their skills and knowledge. By doing so, the training aims to ensure better system performance and reduce the reliance on support services, ultimately contributing to the broader goals of digital health transformation in South Africa.

8.3 Methodology

This research adopted an exploratory qualitative approach to investigate *how* and *why* specific challenges arose for MHFL users who joined the system before the nomination form was introduced. Qualitative research methods are instrumental when exploring new or under-researched areas, allowing for a deeper understanding of experiences and processes (Maree, 2019). As noted by Du Plooy-Cilliers et al. (2014), this type of research is well-suited for studying phenomena that have not been extensively examined, such as the impact of MHFL training on reducing organisational-based support tickets. The research study followed the phenomenology design, which focuses on capturing the lived experience of individuals to understand the meaning of their experiences and encounters with the MHFL system (Maree, 2019). Specifically, the study explored the experience of users unfamiliar with the nomination form and how targeted training could address their issues. In line with phenomenology, the study prioritised participants'

description of experience rather than the researcher's interpretation (Maree, 2019). Inductive reasoning was applied to infer theory from the collected data, moving from specific observations to the more general (Yin, 2018). This approach allowed the research to capture insights about how MHFL training could reduce the volume of support tickets. This was a cross-sectional study, analysing data at a single point in time, which made it both time-efficient and cost-effective (Yin, 2018).

The research study applied a literature review, in which other authors provided previous scientific evidence to gain insight into the phenomenon to support the exploration of MHFL training (Yin, 2018). Various academic sources were used to search for the literature, including books, conference papers, theses, dissertations, and the Internet. Databases such as ScienceDirect, IEEE Xplore, Scopus, ProQuest, Web of Science, and Google search engines were used to search for relevant studies published between 2014 and 2024. Key search terms included *Master Facility List*, *Training for health professionals, Support Tickets, Training as an educational tool, End-user training, Importance of Support and Maintenance*. This literature review helped identify critical themes, particularly around training and its impact on the support and maintenance environment and handling support tickets. Following the literature analysis, the terms that appeared most frequently in the literature can be seen in Figure 8-1 below.

Figure 8-1: Summary of terms mostly used in this chapter (WordCloud, 2024)

In addition to the literature review, primary data was collected through an online open-ended questionnaire. Yin (2018) explains that open-ended questions are mainly used in qualitative research to allow participants to express their experiences and thoughts freely. Lime Survey as a

software tool was applied for this purpose. The Lime Survey was conducted from 19 February – 28 February 2024, and eight (8) participants completed the survey.

Non-probability sampling methods, including snowballing, convenience, and purposive sampling, were employed to select participants based on their availability and expertise in ICT and the Maintenance and Support Helpdesk environment. As non-probability sampling does not aim for statistical representation but rather to gain insights into real-world phenomena, it was appropriate for this exploratory study (Kumar, 2018, p. p194). Participants' roles Participants included Access Control Manager, Support and Maintenance Supervisor, Information Systems Practitioner, Technical Support, and MHFL System Administrator. Their experience ranged from 1 to over 17 years in these roles, providing diverse insights into the challenges faced by MHFL users (Table 8-1).

Ethical considerations were central to the research process. The participants in this study provided informed consent before being included in the study. Using telephonic and email communication, the purpose of the study was explained clearly to participants. The participants were free to withdraw from the study at any time if they felt uncomfortable, and they were free to decide whether to take part. Participants in the study did not receive any compensation for their participation, and no harm happened to them. Maintaining anonymity and ensuring participant confidentiality was always protected during the data collection was imperative. All participant information was collected and handled confidentially and anonymously.

Table 8-1: Participant Profile

Position	Years of experience	Number of participants
Access Control Manager	3	1
Support and Maintenance Supervisor	6	1
Information Systems Practitioner	4	1
Technical Support	1-17	4
MHFL System Administrator	>10	1

8.4 Literature Review

This section explores the key concepts derived from the chapter's title, focusing on the importance of training, the role of current online training, and the factors that contribute to both unsuccessful and successful training outcomes. It also examines the importance of support and maintenance and user experience from a support and system interaction perspective.

8.4.1 The Importance of Training

Training is a fundamental component in all organisations, serving as a strategic tool for organisational development and ensuring seamless operations (Jevana, 2017). As Malhotra (2017) notes, training improves the quality of work life and enhances organisational development. In the information systems (IS) context, Havelka and Rajkumar (2019) define training as systematic

initiatives that equip individuals with the foundational knowledge and skills to effectively use technology-based systems, leading to improved decision-making and job performance. In healthcare information systems, end-user training is critical during the implementation phase, as it fosters skill development, improves self-efficacy, and encourages system adoption (Ma et al., 2020). Norberg (2015) highlighted that regular training opportunities are significant, especially when users face challenges due to system updates or new functionalities, such as the MHFL's nomination form. Previous MHFL users who did not receive initial training on the nomination form would benefit from recurring training sessions to better understand the form and reduce support-related tickets.

Training also plays a crucial role in fostering deep learning, as Tan & Le (2021) noted. For MHFL users, specialised training focusing on the nomination form is essential to deepen their understanding of its importance and implications. Retraining and up-skilling are critical, especially when technological changes affect job functions (Nedelkoska & Quintini, 2018). MHFL users come from varied organisational backgrounds, and many have different levels of computer literacy. Therefore, regular training sessions are vital for retraining and equipping users with the necessary skills to reduce errors and improve system interaction. Further, focused and thorough end-user training is essential for ensuring the successful implementation of any information system, leading to improved user satisfaction and system adoption (Anderson et al., 2015). Addressing MHFL users' specific challenges, such as the nomination form and targeted training, can lead to more effective system use and better organizational outcomes.

8.4.2 Online Training

Online training provides numerous advantages, including standardising content delivery, customising information for different audiences, and offering flexible scheduling options to accommodate users' work commitments (Gayed et al., 2019). Online platforms also allow users to revisit course materials, which improves information retention and learning outcomes. For healthcare professionals, online and technology-mediated learning offers sustainable development opportunities, especially when in-person training is logistically or financially challenging (Stone-MacDonald & Douglass, 2015). The flexibility and accessibility of online training enable users to participate irrespective of their geographical location, making it particularly useful in large, distributed healthcare systems such as the MHFL (Mahdavi Ardestani et al., 2023).

Studies by Frensley et al. (2017); Gillespie-Lynch et al. (2015) further highlight that online training can be re-used at no additional cost to the users, allowing for scalable and sustainable training models. For the MHFL system, training is conducted online at no cost, and users receive regular invitations to participate in these sessions, irrespective of their location. This ensures access to essential training for all users, including those in remote areas, reinforcing the system's inclusivity and scalability. According to Mahdavi Ardestani et al. (2023), the healthcare education landscape has been transformed by e-learning, providing professionals with training and developmental

prospects, irrespective of their geographical location. This flexibility is especially critical for the MHFL, as it allows healthcare workers to receive timely and relevant training to keep up with system updates and new features, such as the nomination form.

8.4.3 Factors that influence unsuccessful training

The section below focuses on understanding the factors that influence unsuccessful training. The importance of this section is to provide insight into how the MHFL training managed to mitigate these factors while also understanding how literature findings discussed these factors.

Lack of Skill Transfer – One of the key objectives of training is to ensure that learners can apply the skills and knowledge they gain in their work environments. Poor training may result in participants being unable to apply what they have learned, leading to minimal improvement in performance (Cleveland & Cleveland, 2020). Alcivar and Abad (2016) note that conventional training methods often fail to deliver substantial learning outcomes, resulting in neutral or low user satisfaction. In contrast, MHFL training has been designed to ensure skill transfer, as evidenced by the interactive questions and answers (Q&A) sessions. After attending the training, users actively engage with the MHFL system, demonstrating that the intended skills transfers have been achieved.

Poor Engagement and Motivation – Training programs that do not engage participants or fail to foster active participation are often ineffective. Low engagement can lead to poor retention of information and dissatisfaction with the training experience (Hobbiss et al., 2021). Online training can be prone to disruptions, leading to lower attention spans compared to in-person sessions (Belaya, 2018). Additionally, it will be challenging to determine whether participants are engaged, paying attention, and not getting sidetracked by things that would not keep them from paying attention during an in-person training session (Peñarrubia-Lozano et al., 2021). Belaya (2018) posits that many online training participants experience anonymisation and isolation. The MHFL training is divided into two training sessions: the first half of the training addresses the crucial theory aspect of the MHFL and the second session focuses on the system demonstrations, each session ends with a question and answer (Q&A) section that allows users to ask questions. The inclusion of a chat box for anonymous questions ensures that all users can engage with the training, even if they are uncomfortable verbalizing their questions.

Negative Feedback and Low Satisfaction – Participant feedback significantly indicates training effectiveness. Negative feedback regarding the training's content, delivery, or relevance suggests that the program has failed to meet participants' needs (Shi et al., 2023). The MHFL training includes a quiz to test participants' knowledge and an evaluation form that allows participants to provide feedback on the training's effectiveness. The consistently positive feedback received indicates that users are satisfied with the training they received.

Failure to Meet Learning Objectives – Training programs should have measurable learning objectives. When most participants fail to attain these objectives, the training can be considered ineffective (Pegram et al., 2022). Karimi et al. (2015) emphasised that training is a platform for users to form their initial impressions of the system. In the case of MHFL training, the learning objectives are always met, as demonstrated by the active engagement of users across various facilities. This is reflected in their ability to navigate the MHFL system effectively after attending the training.

Connectivity Issues – In South Africa, network connectivity remains a significant barrier to successful online training. Poor bandwidth can disrupt online sessions, making it difficult for participants to access content in real-time (Graves et al., 2021; Mthethwa et al., 2023). MHFL training addresses this challenge by providing recorded sessions to users who experience connectivity issues, ensuring they can review the material at their convenience.

This chapter advocates for the MHFL user training that specifically addresses the issues of the previous users of the MHFL, which were caused by the introduction of the onboarding nomination form after these users onboarded the system. Users will then have access to both trainings where one focuses on the users of the MHFL, addresses the issues encountered by users and the overall functionality of the system, while the other focuses on addressing specific issues that arise as a result of the system improvements and the nomination form.

8.4.4 Factors that influence successful training

Clear objectives, interactive engagement, and practical application characterise successful training. This section discusses factors contributing to successful training, drawing from the literature and the MHFL experience.

- Targeted Education – Schirmer et al. (2023) found that targeted, needs-based training encourages end-users to participate in digital technologies more effectively. Similarly, Ahmad et al. (2022) emphasises the need to provide training programmes designed for user needs to facilitate efficient learning. MHFL has targeted training for facility representatives and curators. There is a need to extend targeted training to previous users for the nomination form.
- Good connection – Successful online training depends on stable internet connectivity, which ensures the continuity of the training session and reduces disruptions (Chen et al., 2018). In MHFL training sessions, when good connectivity is available, the presentation has minimal interruptions, and the trainer's vocal audio remains clear throughout. This contributes to the overall success of the training.
- Active Participation – Imms et al. (2017) define participation as meaningful involvement in a life situation. Successful training should foster opportunities for participants to engage with the content and ask questions actively. The MHFL encourages active participation by

offering users the chance to ask questions after the theory and system demonstration segments. Additionally, participants can take an anonymous quiz designed to test their understanding and provide feedback about the training. That feedback is used to identify areas of improvement in the MHFL training. Furthermore, The MHFL also holds a Q&A User-Led session, allowing users to guide the discussion based on their experiences.

- Time Management – Time management is essential to the success of any training session. According to Chaudhari (2022), efficient use of time promotes learning and allows participants to engage with the material thoroughly. In MHFL training, sessions are carefully timed to end within the stipulated timeframe, ensuring participants remain engaged. However, if the session runs over time, participants tend to drop off before it concludes. Additionally, MHFL training sessions are automatically cancelled if fewer than eight participants attend within a predetermined period, ensuring that training is only conducted with engaged, active participants.

The factors influencing successful and unsuccessful training are vital to understanding how the MHFL training has been shaped to meet the needs of its users. By addressing issues such as poor engagement, lack of skill transfer, and connectivity challenges, MHFL training has managed to create a more effective learning environment. The success factors, such as targeted education, good connectivity, and active participation, have further strengthened the training's impact, contributing to reduced support tickets and improved user satisfaction. Moving forward, MHFL training can continue to enhance its effectiveness by extending targeted sessions to address the specific needs of previous users, ensuring that all participants are equipped with the skills necessary to navigate the system efficiently.

8.4.5 The Importance of Support and Maintenance

The service desk is an essential unit within all modern organisations because it serves as the first point of contact when customers require information or face challenges with an organisation's services (Bosu et al., 2019). Some factors need to be considered to ensure the best support is offered to customers, and these include:

- Responsiveness is an important point that affects the customer. The diminution refers to the inclination to support and help customers by delivering quick service. Quick responses by companies will attract customers by dealing more with customers' needs, questions, etc. All these points will improve the relationship between customers and service companies (Ali et al., 2021). The MHFL support aims to respond to tickets in 2-5 minutes to acknowledge a ticket logged by the customer or end user with a 24-hour turnaround time to resolve the overall request, depending on the requirements.
- Reliability is the capacity to constantly and precisely achieve the promised service. The MHFL support team strives to embody this throughout the communications with end users.
- Service Quality is traditionally defined as the quality of the support users receive from the

IS department and IT support system (Alshamrani, 2018; Poerjoto et al., 2021; Sharma & Sharma, 2019). Quality service is a critical issue to customers and business owners, which affects the customer's satisfaction and can decide if a customer would return or not to buy the same product or service. Service refers to essential features of the service, while quality refers to using mainly a user-based approach (Faraj et al., 2021). The MHFL support team strives to offer quality services to the MHFL users to ensure customer satisfaction.

- Inadequate Service Quality means less trust, loss of loyalty, and customer dissatisfaction. Inadequate service quality results in less productivity due to fewer profits and less customer satisfaction and loyalty (Faraj et al., 2021).

As a critical information system, HIS relies on a robust support infrastructure to ensure seamless operation and promptly assist users. In the ever-evolving landscape of digital healthcare, the importance of support cannot be overstated. We are witnessing a shift into the digital age, where support is not confined to resolving issues related solely to computer networks, operating systems, or internet connections. Instead, it has become a cornerstone in corporations, institutions, and various organisations, addressing various challenges that may arise, encompassing computer security and various software/hardware issues (Aglibar et al., 2023). In the context of the MHFL, this support is indispensable to navigating healthcare data management's complexities ensuring accuracy, security, and interoperability within the dynamic digital ecosystem.

The MHFL support team employs a systematic approach, utilising a ticketing tool to swiftly identify and address any emerging issues, particularly those that persist over time. Users initiate contact with the MHFL service desk to log a request by emailing HIS-SUPPORT@health.gov.za, and tickets are generated using the osTicket system. The Support Agent is responsible for communicating with the customer regarding the tickets and implementing the necessary changes (Bosu et al., 2019). In MHFL support, the Technical Support team manages the service desk operations, utilising osTicket as the support tool to address technical issues and client inquiries effectively. Per the findings of Bosu et al. (2019), the service desk is responsible for resolving all issues submitted through osTicket, ensuring the MHFL operates seamlessly and provides accurate and up-to-date information about healthcare-related queries. Following the submission of a request, the customer can track its progress. Support agents also create knowledge-based articles to assist clients in finding information on issues reported by previous clients and resolved. Customers are expected to use this feature and create requests only when they cannot resolve their issues after searching the knowledge base (Bosu et al., 2019). Users of the MHFL can follow up on the status of their request; similarly, the support agent can provide feedback to the user.

8.4.6 User Experience

Excellent user experience is essential for any product to succeed commercially in the current competitive environment. User experience is highly subjective, and measuring it is theoretically challenging (Schrepp et al., 2014; Schrepp et al., 2017). Nonetheless, it's critical to measure this

attribute precisely, given its significance. For instance, this measure could be utilised to determine whether a product is stronger than the competitors or offers a better user experience (Schrepp et al., 2014; Schrepp et al., 2017). According to Heshmati et al. (2021), problems with usability and user experience lead to user dissatisfaction, negatively impacting the effectiveness and adoption of clinical and public health information systems. Better usability can increase productivity and well-being while lowering stress and the possibility of harm to users or those impacted by a system's actions. Usability is a crucial component of software quality (Maqbool & Herold, 2024). Information systems with poor usability are less frequently used and are less likely to be accepted by users. As a result, there will be less trust in information systems, lowering satisfaction, effectiveness, and efficiency (Jeddi et al., 2020).

The MHFL strives to ensure an excellent user experience through system interaction or user support requests. The MHFL undergoes extensive testing and evaluation to ensure efficient system functionality and improvements for the user's benefit. Microsoft Teams meetings with users are scheduled to explain the process, recreate the error, and troubleshoot the problem. In addition, Jeyakumar et al. (2021) recognised that information technology users often face a significant learning curve during initial implementation, requiring several years to become experts in system features. This is evident in the MHFL as previous users encounter challenges with the nomination process and find it intricate or extensive. Jeyakumar et al. (2021) suggests that users' attitudes toward system use during the initial stages can offer valuable insights into how the system will be utilised later.

Consequently, education remains critical in understanding the benefits of HIS and achieving value-added use, particularly during the adoption or early phases of implementation (Jeyakumar et al., 2021). Furthermore, the active involvement of end-users is crucial in crafting HIS that proves beneficial for clinicians and seamlessly supports their day-to-day tasks. Nevertheless, limited research has delved into end users' encounters during HIS development and their favoured modes of involvement in this process (Martikainen et al., 2020).

8.4.7 The Master Health Facility List (MHFL)

The section below is derived from the Council for Scientific and Industrial Research (CSIR) unpublished reports and an updated living document when required. This living document was developed mainly for the end users of the MHFL, specifically curators and facility representatives. The end users of the MHFL also have access to this document through training slides presented in the online training every month. The end users receive links to portals where they can access the training slides, which are saved in the MHFL under reference material for easy access and are downloadable when required, as per the figure below:

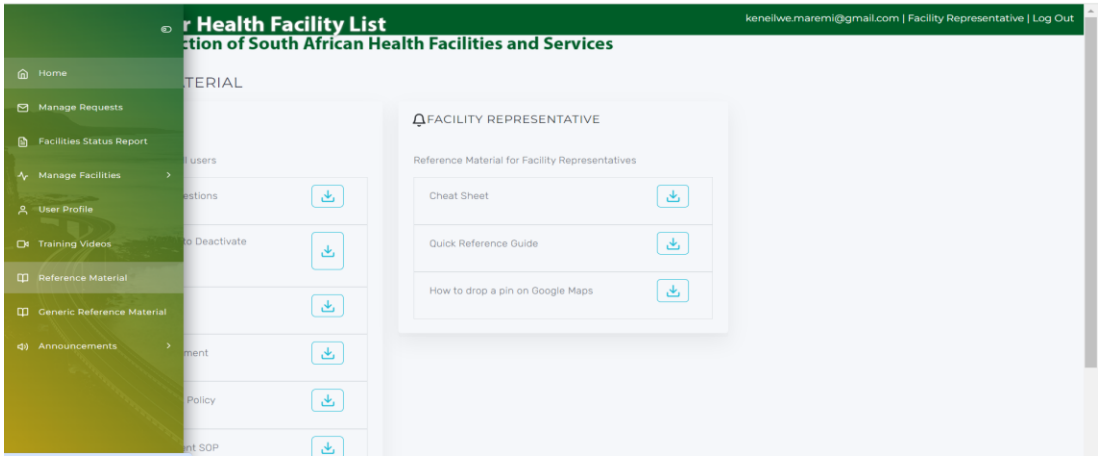

Figure 8-2: MHFL Reference Material

End users have two (2) roles: The MHFL Health Facility Representative and the Curator. MHFL health facility rep is an individual designated by an institution/ facility/ company to serve as an MHFL user. It is responsible for editing or adding facility details (e.g. Facility Manager) (NDoH, 2021). The following are the tasks required of them:

- Create requests to add or edit facility details such as vaccine services and outreach services.
- Register themselves on the MHFL to gain access.
- View all facility data.

Similarly, an MHFL curator understands the facility well enough to review and confirm that the data captured by the health facility rep is correct (NDoH, 2021). A new (or edit) facility request is sent to the curator on the MHFL for review and is either reviewed successfully or rejected. The 'successful review' confirms that the vaccine site complies with the requirements. This person requires authentication. The MHFL system is also configured to allow a facility to have at least one health facility rep and one curator. However, two or more facilities can share a curator, but a person cannot hold two roles of being both a facility rep and a curator for a single facility (NDoH, 2021).

For these end users to be granted access as users of the MHFL, they must complete a nomination form, and an MHFL coordinator must submit it to HIS-SUPPORT. Each organisation identifies an MHFL coordinator who serves as the focal person for MHFL between the organisation or province and the National Department of Health (NDoH). They are responsible for nominating or communicating with the organisation's MHFL health facility rep or Curator (NDoH, 2021).

As shown in Figure 8-3, the nomination form is used to onboard the MHFL. The following steps are taken using the form:

- The MHFL Curator and facility rep undergo a nomination process before they can be

granted access to the MHFL.

- They are nominated by their relevant organisations or departments' MHFL coordinators.
- For approval, the MHFL coordinator must email a consolidated MHFL user nomination list to NDoH at (HIS-SUPPORT@health.gov.za).
- The organisation must have a service delivery model in place.
- A health facility rep will then register themselves in the system.
- A Curator will be added to the system internally by the MHFL System Administrator.
- A temporary password will be sent to the email address on the form so the user can access their account on MHFL.
- The nominated MHFL facility rep can add/edit a facility and link it to the organisation or Department's name.
- The MHFL Curator can see the added or edited facility in the queue for review.

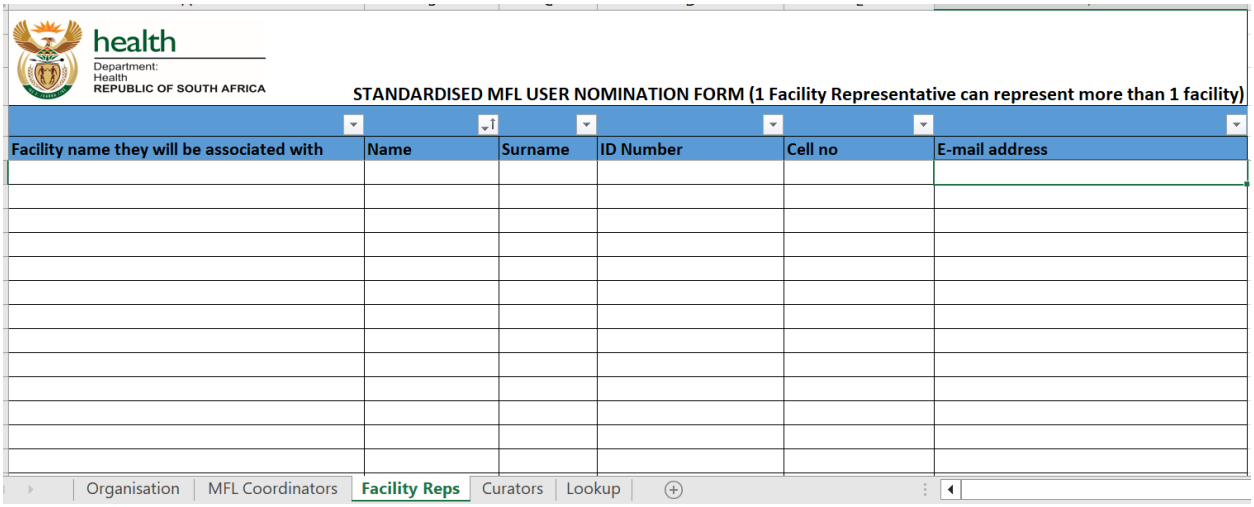

Figure 8-3: MHFL Onboarding Nomination Form

8.4.7.1 Implications of the nomination form

Due to the number of support-based tickets received daily through HIS-SUPPORT. This onboarding nomination process has proven to be a big problem for previous users of the MHFL, as when they initially joined the system, this form was non-existent. The implications of the nomination form are presented in the part that follows. This section is based on observations made by HIS-SUPPORT regarding the volume of tickets received daily.

- *First implication:*

When a user resigns from the organisation – the onboarding nomination form procedure is followed to register a new user. The onboarding process is straightforward for users who used the nomination form because the MHFL system administrator has already created a OneDrive list on their behalf. All MHFL coordinators have access to this list, which they can update with the information of a new user who wants to join the system and remove the information of a resigned user. In addition, the MHFL coordinator resubmitted the nomination form to HIS-SUPPORT. Upon receiving this request, the system administrator deactivates the user's account who resigned and advises the facility rep to register themselves on the system. The facility rep then navigates to the MHFL system to register themselves. They click on the register user button as per Figure 8-4. A form pops up, and they are required to populate their information and choose their organisation. Following this, the MHFL system administrator reviews the nomination form to ensure the information in the system provided by the facility representative is accurate and matches the information on the nomination form. Upon confirmation, they review the account and forward it to the MHFL approver, who likewise authorises it after cross-referencing the data with the nomination form.

Regrettably, users who joined the system before the nomination form was introduced find this process problematic. Firstly, although the previous users had access to the system, the system administrator will not acknowledge their account as their organisation is unknown to the MHFL team. Secondly, should the facility rep proceed to register, they won't be able to select their organisation from the list of organisations in the MHFL, as it will not appear. If they choose the incorrect organisation and still register, their request will remain pending review on the system, leading to numerous support tickets about this request. The proper procedure is understanding and comprehending how the onboarding nomination form functions. After that, proceed with the onboarding process. The user will receive a temporary password in their registered email address to log in to the system after their account has been reviewed and approved.

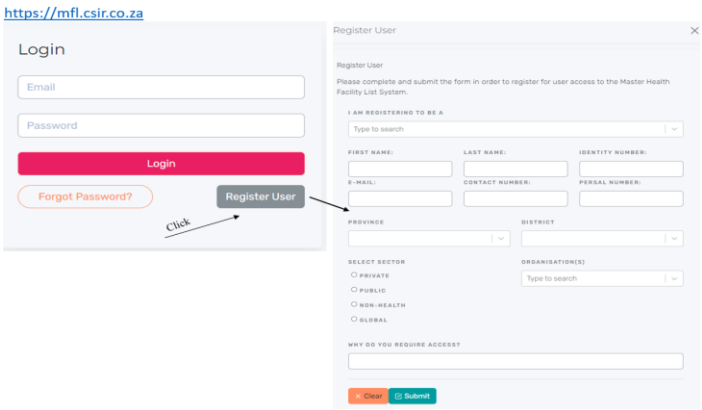

Figure 8-4: MHFL Registration Page

When a curator resigns, the system administrator must be notified; the nomination form is the only way to do this. After the form is received through HIS-SUPPORT, the system administrator deactivates the resigned user's old account and creates a new one per the nomination form. When the curator's account has been reviewed by the second system administrator, who confirms that the information matches the nomination form, the account is sent to the MHFL approver, who goes through the same procedure to verify that the information on the system matches the nomination before approving the account. Following approval of the account, the curator then receives a temporary password to log into the MHFL.

- *The second implication:*

The username is used to register end users in the system. Unfortunately, when an end user uses an email to register on the system, this email address serves as a username for the MHFL account. If a user decides to change this account, they cannot simply edit the username from their profile instead they need to go through the nomination process so the old account can be deactivated, and a new one can be registered on the system by the respective users. This also proves to be a problem for previous users as they received accounts before the introduction of the nomination form.

- *The third implication:*

Organisation association – an MHFL health facility rep can only edit, add or deactivate facilities that belong to their organisation. Should the organisation differ from the facility, the error below would appear.

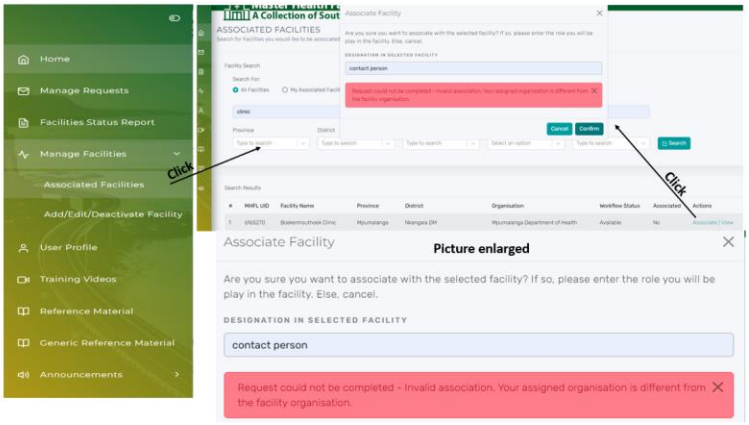

Figure 8-5: MHFL Organisation Association

The facility rep must then go to their user profile to associate themselves with their organisation, as illustrated in Figure 8-5. However, to finalise the form, the organisation association process must go through the approval process. This creates two (2) problems for previous users.

- The first problem is that the facility rep may not find their organisation on the list

when attempting to associate their profile with their organisation.

- The second problem is that the facility the user wants to associate with so that they can edit or deactivate may be related to an incorrect organisation, such as non-health, private health, or another privately owned organisation.

To address these two issues, an onboarding nomination process is needed. Also, there is a chance these organisations can be rejected, creating concerns and dissatisfaction as users used to have access. Now that the process is streamlined, their account is denied access. Such requests often take days to be resolved, including a great deal of back and forth between the end user, the support and maintenance agent, the MHFL Approver, and the MHFL system administrators from the NDoH.

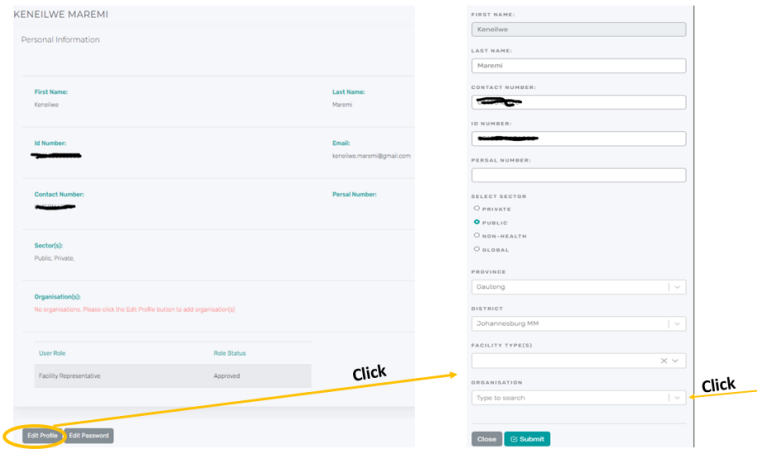

Figure 8-6: MHFL User Profile

8.4.7.2 MHFL Support and Maintenance

The support and maintenance teams are divided into three tiers. At the 1st and 2nd tiers lies the NDoH, which is responsible for handling first- and second-tier requests. Once the issue cannot be solved from their level, they escalate to the 3rd tier level, where normally most requests are resolved. The end users email HIS-SUPPORT, and a ticket is generated to communicate with the support and maintenance team. This ticket reaches the support team via the osTicketing system. osTicket efficiently directs inquiries submitted through web forms, email, and API (osTicket, 2024). The ticket shows the ticket number assigned to the user, the last updated date, the person from whom the request was submitted, and the person to whom the ticket was assigned. All the communications with the end user are done through this system.

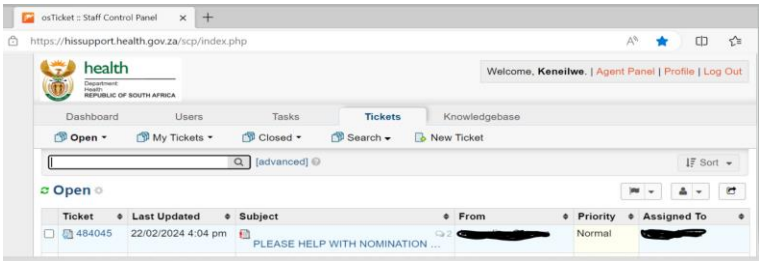

Figure 8-7: osTicketing System

Once the agent receives this request, they identify the problem and escalate it to the relevant personnel to assist, such as the system administrator, the MHFL approver, or the backend team. In between, there is seamless communication between the end user and the support agent regarding the status of their request. Should their request be actioned by either the system administrator or the MHFL approver, the end user will receive communication throughout the account stages. Eva et al. (2016) pointed out that some level of challenge or unease is expected during a transition period, as observed by the increase in MHFL support tickets related to organisational association. However, introducing a comprehensive assessment system could mitigate the difficulties linked with this transition. This system can enable supervisors, mentors, and coordinators to access high-quality information regarding each person's strengths and weaknesses, making it feasible to create additional educational opportunities efficiently. This strategy enhances the likelihood of addressing any issues that may arise as individuals advance to the next stage of training, promoting a smoother experience and support.

8.5 Results

Eight professionals from the support and maintenance department and the MHFL training environment participated in a survey study to provide thorough input that will enhance the user experience and the overall MHFL system. The professionals who were presented with survey questions (SQ) are from different MHFL Support and Maintenance team tiers. They are all exposed to the different support tickets logged by end users. Most of the time, the 1st tier level knows little about the request but knows when to escalate (Mottesi, 2023). At the 3rd tier level, these professionals understand the main course of the problem. Thus, the outcome of the results section will be different based on the various levels of expertise, which are provided in Table 8-2 below.

Table 8-2: Outcome

Question	Result
MHFL training allows users to comprehensively understand the entire system, including new features and updates. Please rate this statement based on your knowledge or experience.	There was agreement among all participants, with 75% strongly agreeing with the statement.
Incorporating the nomination form into the MHFL training session ensures that staff receives targeted education about its purpose, use and importance.	As a result, 37.50% of participants strongly agreed with the statement, and 62.50% agreed.

Question	Result
Please rate this statement based on your knowledge or experience.	
A separate training that targets previous users and the importance of the nomination form is essential to reducing support queries relating to the nomination form.	All participants accepted the statement, with 62.50% strongly agreeing.
Educating previous users on the nomination form through MHFL training helps reduce the number of organisational-based support tickets related to form-related issues or queries.	This resulted in 87.50% of participants strongly agreeing with the statement, which was the highest percentage.
Through the MHFL training, users are provided with clear explanations, demonstrations, and practice opportunities that can increase user confidence in their daily workflows.	The results of this statement showed that 62.50% strongly agreed, 12.50% agreed, 12.50% disagreed, and 12.50% neither agreed nor disagreed.
The MHFL training sessions have reduced support tickets, resulting in time and resource savings, with support personnel focusing on addressing other support queries.	62.50% agreed and 25% strongly agreed. 25% strongly disagreed.
Educating previous users to nominate representatives properly contributes to the accuracy and completeness of the MHFL databases, leading to improved system performance and data reliability.	There was agreement among all participants, with 62.50% strongly agreeing with the statement.
The MHFL training sessions provide opportunities to gain feedback from all users on their experiences with the nomination form to identify areas of improvement to streamline system usage and optimise user satisfaction.	In response, 25% of participants said they were neither in agreement nor disagreement with the statement, 50% said they agreed, and 25% said they strongly agreed.

From the results, it is evident that most users, whether old or new, agreed or mostly agreed that the MHFL training sessions resulted in fewer support ticket queries and allowed them to provide feedback on their experiences to improve the MHFL system performance and optimise user satisfaction.

8.6 Discussions of Results

The primary objective of the online survey was to gain insight into participants' experiences with the MHFL system, focussing on managing support-related tickets and the MHFL training. Participants provided valuable feedback on how MHFL training serves as an educational tool to reduce the number of organisational-based support tickets, particularly for users who joined the system before the nomination form was introduced. This section discusses key findings based on the survey questions (SQ) and their alignment with the literature review.

SQ1. MHFL Training allows users to comprehensively understand the system, including new features and updates.

Participants indicated that MHFL training effectively details the system's functionality and provides users with the necessary skills to navigate new features and updates. The training includes

system demonstrations, ensuring users have the confidence, information, abilities, and know-how required to perform tasks efficiently. Users also have the opportunity to rate trainers, which helps enhance future training sessions. Malhotra (2017) also agrees with the significance of training as he posits that training acts as the foundation to guarantee the smooth execution of the work.

> *SQ2. Incorporating the nomination form into the MHFL training ensures users receive targeted education on its purpose, use and importance.*

The participants' feedback highlighted the nomination form's critical role in accessing the MHFL system. Without the nomination form, users cannot be approved in the system. Including this form in training sessions ensures that users fully understand its significance, thereby streamlining the approval process. A thorough understanding of the nomination form leads to more efficient system use and fewer mistakes, ultimately reducing support tickets. As Schirmer et al. (2023) recommended, targeted training for specific system improvement further supports this approach.

> *SQ3. Separate training for previous users, focusing on the nomination form, is essential to reduce support queries related to the form.*

Participants expressed that the existing two-hour training is often too long, with many users losing interest before and during the nomination form section. As a result, users who previously attended the training tend to disengage when the nomination form is discussed. Offering a separate, focused training session on the nomination form will help users understand what's needed, which will reduce support tickets related to the nomination form. Offering a separate, focused training session on the nomination form will help users understand its implications and reduce related support tickets. Participants noted that the nomination form is fundamental for MHFL user onboarding, and retraining previous users is critical to minimising delays in the approval process and ensuring smoother system operations. This finding is in line with recommendations from Imms et al. (2017) on the importance of refresher training for maintaining system proficiency.

> *SQ4. Educating previously about the nomination form through MHFL training helps reduce organisation-based support tickets related to form queries or issues.*

Participants emphasised that training on the nomination form encourages users to complete it accurately and ensures that the correct person, typically the MHFL coordinator, submits it to HIS-SUPPORT. Proper submission reduces delays in user approval and system access. Participants also commented that training previous users on the nomination process is critical, as understanding the form is essential for fully utilising the system. This reinforces the need for specialised MHFL training focused on the nomination form, as also suggested by Schirmer et al. (2023).

> *SQ5. MHFL training sessions provide clear explanations, demonstrations, and practice opportunities, increasing user confidence and willingness to utilise the form in their daily workflows.*

Feedback on this question was mixed. While many participants agreed that the training provides clear explanations and demonstrations, a minority expressed confusion, stating that users often seem unsure despite repeated sessions. One participant noted that users sometimes remain confused, highlighting the need for more regular, targeted training.

Despite these challenges, most participants agreed that the training effectively builds confidence and familiarity with the system. The MHFL training is divided into two sections: one focuses on the theory part of MHFL, and the other focuses on the practical, the system demonstration. Users obtain the knowledge of the system and how to navigate the system.

> *SQ6. MHFL training sessions have reduced support tickets, resulting in time and resource savings*

Not all participants agreed with this statement. One participant acknowledged that while support tickets are still logged, training has helped address some recurring issues. Other participants agreed that MHFL training had resolved many systemic difficulties during the Q&A sessions, allowing support teams to focus on other critical tasks, such as cleaning MHFL facility data. Although the number of support tickets related to nomination forms and organizational associations remains high, the overall number of tickets has decreased, aligning with the current state of the MHFL.

> *SQ7. Educating users on how to nominate representatives correctly contributes to the accuracy and completeness of the MHFL databases, leading to improved system performance and reliability.*

Participants emphasized the importance of educating previous users on the correct process for nominating representatives. Completing the nomination form ensures data integrity, leading to faster approval times and enhanced system reliability. Participants noted that when users understand the significance of their role in data entry, they are more likely to provide accurate information, contributing to the overall completeness of the MHFL databases. Ahmad et al. (2022) also emphasizes the value of targeted training for reducing system errors and support tickets.

> *SQ8. MHFL training sessions provide opportunities to gather feedback from users on their experiences with the nomination form to identify improvements*

Participants agreed that MHFL training allows users to provide feedback on their experiences, which is essential for identifying areas for improvement. Through training evaluations, users can rate facilitators and highlight areas requiring clarification. Training sessions also offer a platform for users to share best practices and lessons learned, enabling improvements to the nomination process (Chaudhari, 2022). This feedback loop is critical for enhancing the overall user experience and optimizing the MHFL system.

8.7 Recommendations

Based on the insights gathered from the survey and analysis, the following recommendations are proposed to enhance the effectiveness of the MHFL system, particularly in addressing the challenges faced by previous users and reducing the volume of support tickets related to the nomination form:

- Identify and Target Previous Users for Specialized Training: Compile a list of users who onboarded the MHFL system before the nomination form was introduced. These users should be invited to a dedicated training session focusing on the nomination form and its implications for system use. This will ensure that those unfamiliar with the form receive targeted education, reducing the need for ongoing support and improving their ability to navigate the system.
- Develop and Deliver a Nomination Form-Centric Training Module: Create a specialized training module that focuses solely on the nomination form, including its purpose, correct usage, and the approval process. This module should emphasize the importance of accurate and complete form submission, which will help streamline user onboarding and minimize form-related errors and support requests.
- Appoint Dedicated Facilitators for Nomination Training: Assign a designated facilitator responsible for overseeing all training sessions related to the nomination form. This person should have in-depth knowledge of the MHFL system and the nomination process to ensure effective and consistent delivery of the training material.
- Incorporate Organization-Specific Training Sessions: Offer training sessions tailored to individual organizations' needs, ensuring users feel comfortable asking questions about their workflows. Organization-specific sessions can provide a more relevant and engaging training experience, increasing the likelihood of effective system use and reducing support tickets.
- Implement Interactive and Practical Training Methods: Make the training more interactive by allowing users to share their screens and demonstrate issues they encounter. At the same time, a facilitator provides real-time, step-by-step guidance. This hands-on approach will help users better understand the system and resolve common issues more efficiently.
- Schedule Regular Refresher Training Sessions: Establish a recurring schedule for training, ideally offering monthly sessions focusing on the nomination form and related system updates. These sessions should be flexible to accommodate specific requests from organizations and users needing additional support. Refresher training will help ensure that users stay updated on system changes and continue to use the MHFL system correctly.
- Enhance the MHFL System's User Interface with Built-In Guidance: Improve the MHFL system by integrating interactive elements that provide users with contextual guidance. For instance, tooltips or pop-ups could explain the purpose and function of each button, tab, and

page. This would reduce confusion, and the number of support tickets related to system navigation.

- Create and Distribute Comprehensive Training Materials: Develop clear and concise training materials, such as guides and instructional videos, focusing on the nomination form and its role in the MHFL system. These materials should be available to all users, allowing them to reference the information as needed. This would reduce dependency on support teams for basic queries.
- Assess Training Effectiveness Through Quizzes and Feedback: Conclude each training session with a brief quiz to assess participants' understanding of the nomination form and other key aspects of the system. Additionally, feedback from users can be gathered to identify areas for further improvement. This feedback can inform future training sessions and ensure they remain relevant and effective.

8.8 Conclusions

This chapter underscored the critical role of training in enhancing system use and improving user experience within the MHFL system. The literature review highlighted the differences between online and in-person training, emphasizing the value of tailored training programs that address specific user needs, such as support and maintenance. The onboarding nomination form, identified as a significant challenge for previous users, was thoroughly examined to understand its impact on support ticket volumes. Aligned with the Digital Health Strategy, mainly focusing on developing a competent digital health workforce to drive economic development, this chapter highlighted the importance of enhancing users' technical capabilities. The proposed MHFL onboarding nomination training specifically targets previous users, equipping them with the skills to navigate the system efficiently. This training is essential in building a workforce capable of fully exploiting digital health technologies, supporting the broader goals of the national strategy for human development. Implementing the proposed recommendations will significantly improve the user experience, and the number of support tickets related to the nomination form will be reduced. Ultimately, this will enhance system performance and contribute to a more robust, digitally capable health workforce, aligning with the broader goals of the South African Digital Health Strategy.

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8.9 Concluding Remarks

The Positive Infusion Strategy demonstrated that a well-structured and phased approach to eHealth system implementation can lead to successful, sustainable outcomes when local stakeholders are involved, and flexibility is maintained. The findings provide a roadmap for future health information system rollouts, ensuring that local ownership and sustainability are prioritized in the process.

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Chapter 9: Change Management made E.A.S.I®

Fabe, P.E[1]

[1]*National Department of Health (NDoH), Digital Health Unit*

Purpose: *The National Department of Health (NDoH) wanted to approach the implementation of the HPRS solution in a different way. The main reasons were that the solution being implemented was of a digital nature and they wanted to scale up the roll out in the shortest possible time. In the past, many digital solutions were point solutions and often only affected a small geographic area, usually owing to a limitation of funding received and, in most cases, were 'proof of concept' or referred to as 'pilot' projects. The HPRS was an ecosystem of implementation in that it not only provided hardware but also looked at re-engineering facility processes to ensure a total acceptance of the solution. The traditional implementation approach took time and buy-in was sometimes tedious. The adoption of the Maturity Model provided a unique way to engage with all stakeholders involved with the solution and change management became the key focus. The E.A.S.I® approach provided a holistic way of being able to achieve the steep targets NDoH had set.*

Study design/methodology/approach: *Change management was identified as a vital ingredient in successfully rolling out the HPRS (Health Patient Registration System). As part of the change management approach, adopting the Maturity Model and the E.A.S.I® approach was included. These two approaches proved valuable regarding buy-in and providing the necessary context for those affected by the implementation.*

Findings: *Change management focused on provincial and district buy-in. E.A.S.I® helped the participants create an emotional connection with HPRS and guided them to set up their own goals based on their unique environment. Helped articulate the reality of where they are versus where they would like to see themselves as a province and district and each delegate had an opportunity to draw up their own implementation plan that could be measured. The workshop was structured in a way where active participation was a requirement, and everyone was eager to partake. The workshops birthed an excitement that seemed to carry over months after the workshop took place. It was also different in that information was not passed on using traditional presentations, as is customary in government, but rather through tailored-made exercises. In Ugu district, we managed to conduct a workshop for over 150 people, including facility staff and the excitement it generated resulted in songs being sung as delegates left the workshop. For many months after this event, Ugu became our star performer and advocate. A nurse close to retirement came over at the end and told us that this was the best workshop she had ever attended in her long service in the department. A true testimony that the change was real.*

Originality/value: *Adoption and implementation of the E.A.S. I® approach assisted greatly in NDoH achieving an extremely high level of buy-in and support throughout the public health sector. Provincial and district buy-in was easily achieved as E.A.S. I® provided a unique way of engaging with a topic, and the workshops proved to be highly interactive and above normal participation, creating an environment where all stakeholders could hold each other accountable.*

Key Words: *Change Management; Maturity Model; HPRS*

9.1 Introduction

Change management is key when introducing a new concept or system into an existing one. In the Digital Health programme, change management took centre stage as the programme ramped up its implementation of the HPRS (Health Patient Registration System) throughout the country. After reaching 657 facilities with HPRS installed, a new approach was needed to reach the remaining facilities. It could be argued that it started the focus on digital health in South Africa by implementing a system that generated a Master Patient Index called an HPRN (Health Patient Registration Number), a forerunner in developing any digital health information system.

The current (2019-2024) Digital Health strategy (NDoH, 2019) does not provide steps on implementation, which is where most strategies fail. The approach taken to deal with change management, as explained in this chapter, is one that can be used with confidence when implementing digital health solutions and could become a key ingredient when the revised digital health strategy is finalised (2019).

E.A.S.I® has been linked to the Theory of change (TOC) concept. TOC can comprise strategies, actions, conditions and resources that can facilitate change. It is often the way desired outcomes are described. In this case, it was used within a specific project to ensure alignment and achievement of goals that could be reached in a complex health environment.

9.2 Initial Steps

The first step was establishing a programme office or PMO (Programme Management Office). The programme office or PMO is the support structure for the Digital Health Information Systems chief directorate. The programme needed to manage the complexity of having multiple partners and role-players within a high-demanding, ever-changing environment. The programme office ensured that the projects and initiatives, which used different approaches/methodologies, were achieving their agreed scope and output targets and that they stayed aligned with the overall strategic intent of the Digital Health Information Systems unit.

The reason for establishing a programme instead of a multi-project approach is based on Table 8-1 on the next page. When a detailed analysis was conducted on the mandate/goal that the Digital Health unit wanted to achieve, it was clear that a programme approach was required to deliver and be successful.

Table 9-1: Business Dimension: Project versus Programme

Business Dimension	Project	Programme
Environment	Relatively stable	Constantly changing
Focus	On time, on budget	Managing the business risk
Goal	Delivery	Benefits realisation
Work orientation	Complex, but containable	Highly complex, interdependent
Structure	Team	Cross-team
Management	Control	Leadership
Control axis	Functions, tasks	Processes, dependencies

It must be said that maintaining a programme view to achieve the Mandate is a best practice and a good management approach. It has shown that implementing a working/functional Information System can only be achieved by establishing a structured environment, the Digital Health Information Systems Programme Office.

Health, in general, is a complex adaptive system. Working in this environment without a previous blueprint in the digital health world brought additional complexity and challenges to the programme.

The Digital Health Information Systems programme consisted of a mixed bag of distinct project types, each using different methodologies and/or approaches. The main goal of the Programme Office is to provide strategic, operational direction, guidance, and quality control for each output.

9.3 Time marches on

Where the programme helped the Digital Health Chief Directorate with the linear execution of HPRS, a new phase of Digital Health had been entered where linear execution no longer defines the work. Demands from various sources within the health sector have become more, and there needs to be a ‘sifting’ of these demands into actual work, which can then be prioritised within the overall context of Digital Health and Digital Health Information Systems and ultimately assist in shaping the revised Digital Health Strategy (2019).

PPM, or Project Portfolio Management, was identified as the best structure to ensure success in this new environment. It also shows how the health sector has matured by adopting Digital Health solutions.

9.3.1 What is PPM?

According to PMI (Project Management Institute), PPM is the centralised management of one or more portfolios that enable executive management to meet organisational goals and objectives through efficient decision-making on portfolios, projects, programmes and operations.

The key difference between programmes and portfolios lies in that operations are added to the mix as the various initiatives, once completed, are handed over to an operational area.

One of the PPM's main functions is to evaluate potential initiatives (projects/programmes), then, if adopted, prioritise them according to the overall strategic objectives of the business.

PPM is simply a tool in the form of a governance structure that assists in better managing large programmes and projects towards a common strategic objective.

9.3.2 Benefits of PPM

Some of the benefits of adopting a PPM approach are as follows:

- Increase project/programme success rate within an organisation. This is done because most business environments have scarce resources, whether people or finance. Initiatives are ranked and prioritised so that only high-ranking initiatives that help meet the overall objectives of Digital Health Strategy goals are appropriately resourced.
- It aids in collaboratively making decisions so that personal preferences are not ranked higher than they should.
- Better Resource Management. Resources are usually scarce, and this vehicle helps better manage resources.
- Minimising Risks/Issues – Risks and Issues are a permanent feature in any project/programme, and using PPM will help minimise and better manage these risks and issues as they arise.
- Budget can be lumped with Resource management; however, it does warrant a separate mention especially as the governance structure for the major funding sources explicitly reports on budget as a separate line item. This is an attempt to bring budgets closer to project outputs.

9.3.3 How to execute PPM?

There are a variety of methods to choose from, and each has unique benefit features however, they pretty much achieve the same result if executed correctly.

One of these methods is the integration of the BCLC (Business Change Lifecycle) into PPM. This works well when businesses need to drive a strong IT component. Figure 9-1 illustrates how this Business Change Lifecycle works.

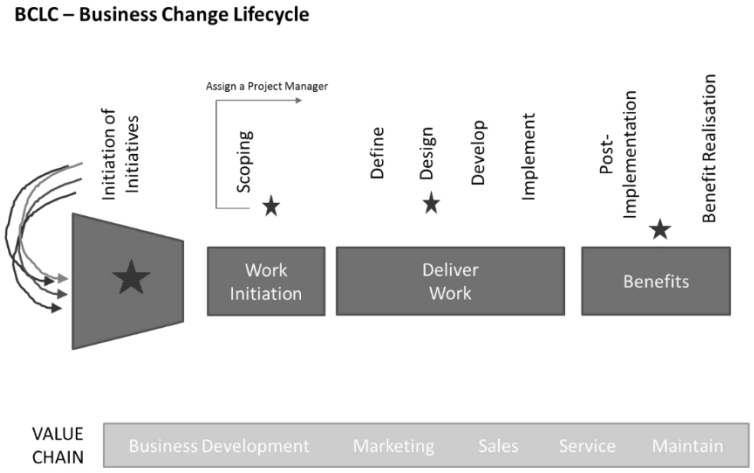

Figure 9-1: Business Change Lifecycle

The initiation of the Initiatives phase can also be called the Alignment phase. It is here where initiatives are (1) Identified; (2) Categorised; (3) Evaluated; (4) Selected; (5) Prioritised; (6) Portfolio balanced, and finally (7) approved to continue.

Point (5) is often ignored in environments that do not score high on the maturity model of PPM. In today's working world, there are insufficient resources, both people and finances and a priority model has not been implemented. The ultimate success of any PPM is dependent on this key point.

9.4 Combining Everything

While the use of programme and project portfolio management was established as the structure governing how projects were executed, how they were implemented into the health system, specifically the public health system, was a major challenge. The status quo of the National Department of Health using a helicopter approach and simply dropping *solutions* was **NOT** the way forward. Digital Health had to deliver solutions that meant something.

To achieve these, two main approaches were identified as *ticking the boxes*. The program adopted a Maturity model, and an approach called E.A.S. I®.

The maturity model provided a framework with which to phase in a solution and measure the success of the implementation. E.A.S.I® is an approach that was used to facilitate change management. It has been said that E.A.S.I® is the *Theory of Change* in action.

It covered four distinct phases: **E**motion; **A**chieve a win; **S**imple & **S**traightforward and **I**mplement.

9.5 Maturity Model

The Maturity Model first appeared in the South African Health Review of 2015 (Wolmarans et al., 2015) and was adopted by the Digital Health Chief Directorate as a framework for implementing digital health solutions.

Figure 9-2 below highlights the levels used for the HPRS rollout.

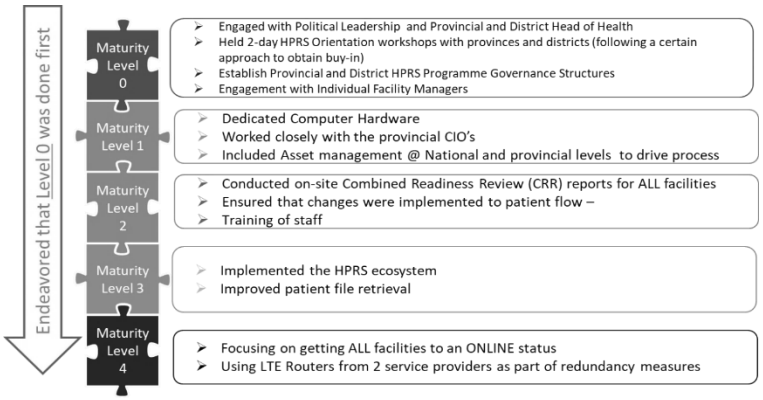

Figure 9-2: Levels used for the HPRS deployment (Adapted from Wolmarans et al., 2015)

The model has five levels, starting with Maturity level 0 and ending with level 4. Each level has specific steps that need to be fulfilled before it can be considered complete. Even though the programme uses an agile approach to project management, level 0 was non-negotiable and completed first before moving to level 1. This is because communication was identified as a key activity for the success of the implementation.

9.5.1 Level 0:

Communication starts with either the DG (Director General) or the DDG (Deputy Director General) sending out a letter to provincial HODs (Head of Department (Health)) informing them of the purpose of the initiative. Communication then goes down to provincial leads, district, sub-district, and facility levels. This is done by arranging E.A.S.I® workshops, called a 2-day HPRS Orientation workshop, attended by province, district, and sub-district representatives.

9.5.2 Level 1:

This level focused on ensuring that the provincial CIOs and the Asset management departments were fully briefed on the HPRS hardware that NDoH donated. Specifications were shared, and a specific asset management process (Asset Transfer process) was followed to transfer the hardware as assets to the province. At the same time, the CRR (Combined Readiness Review) process was started even though it forms part of level 2.

9.5.3 Level 2:

Here, the focus was on assessing whether a facility was ready to (1) accept the donated hardware and (2) assess the readiness of the facility to accept the HPRS ecosystem. The HPRS ecosystem consisted of (1) Patient flow (aligning to Ideal Clinic principles) and (2) a Patient filing system – this was done with two focuses: (a) Implementation of high-density cabinets and (b) making sure that patient folders were filed according to the HPRS filing system (i.e. filing using the last 4-digits of the HPRN (Health Patient Registration Number)). It is at this level where the HPRS hardware was ordered, delivered, and installed. Training of the staff (end-users) was also conducted, and the training was on-the-job training and did not use the traditional venue training.

9.5.4 Level 3:

Here, the HPRS ecosystem is fully implemented, and file retrieval is demonstrated. Many facilities used ID or date of birth to file patient folders, which proved to be an issue, especially when the same birth dates were used. Introducing the HPRN as a means of filing a patient folder meant that duplications were eliminated, and retrieval of files was made easier.

9.5.5 Level 4:

This level focused on connectivity and ensuring that all facilities were online.

As mentioned, some tasks at each level happened simultaneously as the programme followed an agile project management approach. This ensured that implementation could be done much quicker.

9.6 E.A.S.I®

As mentioned, the E.A.S.I® approach was used to facilitate change management and was the focus of level 0 of the maturity model. This approach was gifted to the department and followed a published book called *Strategy is E.A.S.I.* The author of the book is Pierre Fabe.

The approach was delivered using workshops. The workshops were called ‘HPRS Orientation workshops’ and attempted to build (1) an emotional connection to HPRS, focusing on what it is, why it is needed and helping to build an understanding during implementation. The next step was

to work out how to (2) define success. Each workshop, whether provincial or district, focused on how they want to deliver and measure success. This was done through a series of exercises that helped to get the workshop attendees to ensure that reality and expectations were balanced. This led to the following: (3) the 2:3:1 Approach ™ that helps define the *As-Is* and *To-Be* states and immediate steps needed to prepare for the implementation. One of the most interesting aspects of the 2:3:1 Approach ™ was for the workshop attendees to define in a story what is different about where they are now and where they want to be. They also answered the question,

Why do they want to move to the 'To-Be' state?

Finally, (4) the Implementation step worked out who would be responsible for the implementation within the province and what governance structure would be implemented to ensure the implementation goes according to plan.

Overall, the adaptation and adoption of the E.A.S.I® approach helped cement the implementation and directly influenced the success of the implementation of HPRS.

The E.A.S.I® can be expanded to cover various topics and helps form the foundation of concepts in the digital health world. Creating a common understanding is key to successfully implementing any digital health solution. Creating an environment where a large amount of information can be shared with a broad spectrum of people in an environment where learning is fun helps break the divide that often exists between the developers of a solution and the intended users of the solution. E.A.S.I® has been designed so that it can be applied to any topic, concept, or solution, as its core function is to drive understanding and engagement (dialogue).

9.7 Conclusion

The adoption of E.A.S.I® enabled the programme to ramp up implementation. Together with the maturity model, success speaks for itself.

Before these approaches were utilised, it took 18 months to implement HPRS in 657 facilities. Once the approaches were embedded, it took 10 months for an additional 1179 facilities to be implemented and for the final big push, it took 7 months to add another 1151.

The usage of HPRS exceeded all expectations and created a firm foundation for the total number of registrations on the system.

Not only did it benefit the rapid implementation, but it also ensured that success and sustainability were assured through this theory of change approach.

There is a strong case that using the Maturity model, BCLC, and E.A.S.I® is essential for any digital solution to succeed. Digital solutions require buy-in from the users, and they can be seen as overhauling an existing way of working. Resistance to change is a fundamental obstacle that

must be overcome for any digital solution to be successfully used. Successfully used means implementing equipment, uploading the system, and training, and the system can be used with the confidence that it will improve the existing system. You can only do so by having a change management methodology in place.

The Digital Health Strategy needs to move from a paper-based exercise or artefact to one that lives and breathes within the health system. It can only be hoped that the strategy will include a robust change management approach so that it can be realised.

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Chapter 10: Conceptualising Heuristics for Patient Matching through an Integration of Insights from Data Alignment with the HPRS and DHA

Du Toit, K.[1], Fogwill, T.[1], Viviers, I.[1] and Montja, T.[1]

[1]Next Generation Enterprises and Institutions (NGEI) cluster, Council for Scientific and Industrial Research (CSIR), Pretoria, South Africa

Purpose: *The chapter explores heuristic approaches to enhance patient matching within the Health Patient Registration System (HPRS) in South Africa, focusing on integrating insights from data alignment with the Department of Home Affairs (DHA). The aim is to improve the accuracy and reliability of the national patient registry by addressing challenges related to data inconsistencies, cultural naming conventions, and the use of shared identifiers.*

Study design/methodology/approach: *This research adopts an interpretative deductive approach grounded in the principles of ecological rationality. The study systematically analyzes patient matching within the HPRS, examining purposefully selected samples from the over 68 million registered patients, focusing on those verified by the DHA. The chapter proposes a conceptual framework for enhancing patient matching, integrating both deterministic and probabilistic record linkage methodologies.*

Findings: *The findings suggest that employing a combination of key identifiers, implementing referential matching techniques, and developing algorithms that account for cultural and linguistic diversity can significantly improve patient matching accuracy within the HPRS. The research also highlights the importance of addressing data quality issues in both the HPRS and DHA reference datasets to ensure reliable patient identification across health systems.*

Originality/value: *This study underscores the critical role of heuristic approaches in improving patient matching within national health information systems. It contributes to the broader discourse on digital health by offering practical strategies to enhance the integrity of patient registries, ultimately supporting the goals of equitable healthcare delivery under South Africa's National Health Insurance (NHI) scheme.*

Keywords: *Health Patient Registration System (HPRS), Patient Matching, South Africa, Data Alignment, National Health Insurance (NHI), Referential Matching, Digital Health, Heuristics.*

10.1 Background

The South African National Department of Health is rolling out the Health Patient Registration System as the primary national patient registry (Geldenhuys & Botha, 2015; Herselman, Botha, Toivanen et al., 2016). The Health Patient Registration System (HPRS), envisioned as the central patient registry, will be adopted as part of the Health Information Exchange framework being built to support the implementation of the National Health Insurance scheme (NHI Bill, 2019). The HPRS serves as a Patient Registry and Master Patient Index, leveraging the South African identification number and other legal forms of identification.

This chapter explores heuristic approaches to improve patient matching within the HPRS and integrate insights from data alignment with other national health systems, such as the Department of Home Affairs, to enhance the reliability and accuracy of the national patient registry (NDoH, 2024).

The National Health Insurance aims to ensure that all citizens and residents of South Africa, regardless of socio-economic status, have access to high-quality healthcare services provided by both the public and private sectors, thereby eliminating financial barriers to healthcare access (NHI Bill, 2019). This necessitates the creation of robust mechanisms for effective record linkage and data integrity, particularly as empirical findings suggest that integrating diverse datasets can significantly enhance the accuracy and comprehensiveness of patient information, thereby supporting informed decision-making in health service delivery (Bassett, Huang, Cloete et al., 2018).

Tsegaye and Flowerday (2021) argue that in this context, implementing a patient master index is critical, as it can facilitate interoperability among various health information systems. Existing literature suggests that data integration and record linkage approaches can significantly enhance the completeness and accuracy of national health data repositories. However, the effectiveness of these methods largely hinges on the implementation of governance frameworks and standardized protocols that can ensure data coherence across multiple health information systems, especially in regions where resource constraints pose significant challenges to health data management and interoperability (Mutemaringa, Heekes, Smith et al., 2023; Tsegaye & Flowerday, 2021). To achieve this, leveraging probabilistic record linkage models, as well as deterministic approaches that utilise unique identifiers, addresses, and other demographic information, can help mitigate systematic biases and improve patient matching rates across disparate health datasets, ultimately contributing to more equitable health service delivery (Kabudula, Clark, Gómez-Olivé et al., 2014; Mutemaringa et al., 2023; Nevondwe & Odeku, 2014; Tsegaye & Flowerday, 2021).

This research draws on a literature review and insights from stakeholder engagements to propose a conceptual framework for enhancing patient matching within the Health Patient Registration System through integrating data alignment strategies across various national health information systems. The National Health Insurance aims to ensure that all South African citizens and

residents, regardless of socio-economic status, have access to high-quality healthcare services, as outlined in a 2019 Government Communication and Information System report. This universal health coverage initiative is a key priority for the South African government, aiming to provide affordable and equitable access to healthcare services for all. To facilitate this integration effectively, it is vital to establish a national master patient index that not only supports the Health Patient Registration System but also aligns with existing frameworks within the Department of Home Affairs, thereby ensuring that patients can be accurately identified across different health settings and have their medical records reliably linked.

In 2019, the Government Communication and Information System (GCIS) reported that over 20 million patients had been registered on the Health Patient Registration System. To date, that number has significantly increased to more than 68 million patients. Approximately 32.5 million of these patients' names and identification numbers have been verified by the Department of Home Affairs. Entries that the DHA has verified are referred to as having *DHA status verified*.

The National Department of Health has outlined various strategies to improve healthcare interventions, as detailed in the National Health Act (RSA, 2003; Hassim, Heywood, & Honermann, 2008), the Digital Health Strategy(NDoH, 2019a; NPC, 2011; South African National Department of Health, 2003), and the National Department of Health Strategic Plan 2021-2025 (NDoH, 2019b). These strategic documents clearly stipulate the department's responsibility to its citizens and address the challenges the department faces, such as the high prevalence of non-communicable diseases, which account for an estimated 65% of deaths in the country. To tackle these complex health challenges, the NDoH recognises the need for a holistic approach that considers the country's social determinants of health and ensures the implementation of robust healthcare systems (NDoH, 2024).

Since its inception, the HPRS has been used to record and store patient information. However, the data captured within the system has inherent deficiencies, such as data entry mistakes, incomplete or missing data, and duplicate records (Woldemariam & Jimma, 2023). These concerns are often exacerbated by the offline nature of some health facilities, where new patients are registered without the ability to search for existing records online, creating duplicate patient profiles (Woldemariam & Jimma, 2023).

While the paper does not delve into the root causes of these data quality issues, it aims to focus on the actual problems identified within the data and provide insights to address them. The HPRS implements a Referential (Grannis, Williams, Kasthuri et al., 2022). The matching approach utilizes data from the Department of Home Affairs' national population register as a reference. Referential Matching has been shown by Grannis et al. (2022) to outperform traditional probabilistic matching. A key factor in the matching performance is the accuracy of the reference data.

This paper considers the impact of inaccurately captured data within the Health Patient Registration System and examines the influence of anomalies and discrepancies in the reference data from the Department of Home Affairs national population register. The accuracy and reliability of the DHA reference data are crucial factors in the performance of the Referential Matching approach utilized by the HPRS. Therefore, this paper aims to provide insights into addressing the data quality issues stemming from both the HPRS data capture process and the DHA reference data set. In particular, an exploration of the methodologies employed for record linkage—such as deterministic and probabilistic linking—reveals important insights into how these discrepancies can be systematically addressed to enhance overall data quality and improve the patient matching process across health systems in South Africa.

10.2 Methodology

The aim of this paper is to conceptualize heuristics for patient matching through an interrogation of insights into data alignment between HPRS and the Department of Home Affairs. Heuristics refer to cognitive shortcuts or "rules of thumb" that individuals use to make decisions efficiently and quickly (Schwartz, 2010). They enable the navigation of complex problems by drawing upon past experiences and simplified reasoning processes to reach practical and useful solutions within the given context (Albar & Jetter, 2009). While heuristics are valuable in reducing the cognitive effort required to solve intricate problems, they do not necessarily ensure optimal outcomes, as these mental shortcuts prioritise efficiency and speed over exhaustive analysis and precision (Abel, 2003).

Heuristics can facilitate rapid decision-making, allowing the assessment of situations and decision-making without detailed analysis. However, this reliance on heuristics can lead to biases and errors, as decisions are based on limited information or simplified models. In computational problem-solving, heuristics are employed to navigate large solution spaces more effectively in areas like optimisation and machine learning. The methodology often involves using a pool of heuristics to address specific aspects of a problem iteratively. The challenge lies in selecting the most effective subset of heuristics from a larger set, as an overly large or poorly chosen pool can degrade performance. Recent research has focused on developing systematic methods to identify the most relevant heuristics, ensuring that the solutions generated are both effective and efficient, even if they are not perfectly optimal(Swan, Adriaensen, Brownlee et al., 2022). Evaluating the effectiveness of heuristics is considered crucial for understanding and refining their application in complex systems, such as health information management, where decision-making can significantly impact patient care outcomes and system efficiency (Wegwarth, Gaissmaier, & Gigerenzer, 2009).

For this paper, the study examined purposefully chosen samples from the 68,116,903 patients in the HPRS, of which 32,530,697 had their identification number and name and surname verified by the Department of Home Affairs. The paper applied an interpretative deductive approach to

analyse instances of patient mapping, identifying contributing factors for patient identity mismatch (Harding, 1998). This approach draws upon the principles of ecological rationality, which suggest that heuristics, when appropriately tailored to their environment, can facilitate more effective decision-making despite their inherent biases and limitations in information processing (Gigerenzer & Brighton, 2009).

10.3 Data Challenges

Cummins (2007) highlights the critical importance of accurate patient identification, emphasizing the clinical risks associated with different types of registration errors: duplicate registrations, hybrid registrations, and doppelgängers. Duplicate registrations involve multiple entries for a single individual, leading to fragmented medical records, making crucial clinical information inaccessible when needed. Hybrid registrations occur when data from two or more patients are mistakenly merged, either obliterating a patient's record or introducing erroneous details that divide important clinical data across multiple files. The doppelgänger scenario, where two or more patients share similar identifiers, poses the highest risk, as it can lead to immediate and potentially fatal errors, particularly in situations requiring precise patient matching, such as blood transfusions.

Cummins stresses that these errors are not rare coincidences but rather predictable challenges within healthcare systems that require robust identification protocols and systems to mitigate their potentially severe consequences (Cummins, 2007).

The next sections will give insight into specific data challenges identified in HPRS.

10.3.1 DHA verification process

The HPRS incorporates verification of patient details via the Department of Home Affairs. This process involves sending a captured identity number to the DHA and receiving the patient's corresponding registered names and personal details. Interestingly, the results from DHA-verified records have sometimes returned multiple records where the first name, surname and date of birth were identical for different individuals from 2000 to 2009. This suggests potential issues with data quality and duplication within the DHA's national population register, which serves as the reference data source for the HPRS patient matching process.

Table 10-1: Birth Verification

Decade of Birth	# of DHA verified individuals	Total # of DHA verified individuals	Percentage
1920-1929	70	156750	0,04
1930-1939	408	561876	0,07
1940-1949	1082	1254149	0,09
1950-1959	2404	2130667	0,11

Decade of Birth	# of DHA verified individuals	Total # of DHA verified individuals	Percentage
1960-1969	2366	2145726	0,11
1970-1979	4840	2951808	0,16
1980-1989	12304	4047993	0,30
1990-1999	9202	3722490	0,25
2000-2009	37246	8369324	0,44
2010-2019	28694	7070560	0,40
2020-date	34	72787	0,04

Cumming argues that shared forenames, surnames and dates of birth are coincidental but that "[s]uch coincidences are, in fact, not extraordinary, but ordinary" (Cummins, 2007, p. 106).

While having the same name, surname, and date of birth for multiple individuals within the Department of Home Affairs' national population register poses a challenge for accurate patient matching, it is important to additionally acknowledge that not everyone's identity details may be perfectly recorded in the system. This issue, though not necessarily significant in isolation, becomes more relevant when considering the broader context and the need for comprehensive and reliable data for effective health information management (Morris, Farnum, Afzal et al., 2014).

10.4 Names, Surnames and Dates of Birth

South Africa is acknowledged as a culturally diverse nation. Troup's (2022) research highlights the complexity inherent in the orthography of African names, further exacerbated by the country's demographic heterogeneity. Moreover, when examining naming conventions in South Africa, one must consider the influence of cultural, linguistic, and contemporary factors. De Klerk and Bosch (1996)'s study on naming practices in the Eastern Cape Province explicitly investigates the traditions of Xhosa, Afrikaans, and English-speaking communities. Their findings indicate a pronounced patrilineal or matrilineal tendency, which can contribute to the occurrence of duplicate name and surname combinations within the HPRS. Additionally, variations in naming practices and the fluid nature of identity within these communities can lead to further complications in patient matching, as individuals may use different names or surnames at various points in their lives, adding to the risk of confusion and misidentification (Just, Marc, Munns et al., 2016).

Although child naming practices in South Africa are deeply rooted in tradition and cultural factors, there is also a trend to blend traditional names with modern ones to improve children's prospects in a globalised world. Gender also plays a role, with specific names and naming conventions for boys and girls (Makgopa & Rugwiji, 2021; Thwala, 2017).

Spelling and typing errors must also be considered. With eleven official languages in South Africa, system users may find entering details without any mistakes challenging. However, the DHA verification process can rectify these types of errors for South Africans with identification numbers.

If the search criteria only use a surname, the chance of finding duplicates within DHA-verified individuals is almost 100%. However, if the search criteria use first name, surname, and date of birth, the chance of finding duplicates reduces to around 0.4%. This clearly demonstrates the requirement for a group of compulsory variables as part of patient data to improve patient-specific searches.

Table 10-2: Variables in Search Criteria

Combination of Variables in Search Criteria	Percentage chance of getting a duplicate from DHA verified individuals
Only surname	99.5%
Only first names	97.3%
First names and surnames	53.5%
First names, surname and sex	50.9%
First names, surname and date of birth	0.4%
First name, surname, date of birth and sex	0.3%

HPRS records family members; the relationship refers to parents and their children. The recording of these relationships is not compulsory. Usually, children are named after grandparents and not directly to the father and mother unless it is a large family. Using these relationships in search algorithms and duplicate patient identification can possibly improve outcomes.

Patient names on HPRS have been found to have many variables which introduce complexities. Using algorithms to identify and merge duplicates in a population must consider the above findings and practices. Data statistics on HPRS data to understand the complexities will assist in more efficient ways to identify these and to adapt algorithms and/or searches to identify duplicate patients.

10.5 Problematic Characteristics of Human Names

When attempting to match an individual's name to existing records in a database, it is crucial to ensure a consistent and like-for-like approach, such as comparing lowercase characters. According to Just et al. (2016), inconsistencies in data entry, including using uppercase versus lowercase characters, can significantly impact the accuracy of patient matching in electronic health records (EHRs). The challenge is further compounded by special characters within names, which healthcare staff may struggle to replicate accurately. This difficulty underscores the importance of developing systems that handle names with or without special characters, such as accents or hyphens, to ensure effective and accurate matching across diverse populations.

Moreover, Cummins (2007) argues that integrating multicultural considerations into healthcare systems is essential, particularly when dealing with names containing special characters. His research indicates that approximately 2.73% of the population have names featuring such characters, making it imperative for healthcare databases to adopt a tailored approach when

managing these records. This approach should facilitate matching names with special characters and accents, regardless of whether the search is conducted in lowercase or with the inclusion of these special characters, thus enhancing the system's ability to accurately identify individuals within a multicultural context.

Additionally, the interchangeable use of names within different cultural contexts presents another layer of complexity in patient matching. Cummins (2007) highlights the issue of name order variations, where a surname may be employed as a first name or a middle name might be used as a primary name. This variability necessitates the creation of flexible name arrays within healthcare databases, allowing for matching all possible name orders, including using initials instead of full names. Such adaptability is critical to reducing errors and ensuring patient records are accurately linked to the correct individuals.

Furthermore, Just et al. (2016) emphasize the importance of standardizing name entry protocols and search algorithms to accommodate these variations in name usage. By implementing advanced matching algorithms that account for these cultural and linguistic nuances, healthcare systems can significantly reduce the risk of misidentification and the subsequent clinical errors that may arise from mismatched patient records. This approach improves data integrity and enhances patient safety and care quality.

As such, it can be argued that addressing the challenges posed by *special characters*, *name order variability*, and *cultural diversity* in patient identification requires a comprehensive and adaptive approach. By integrating these considerations into the design of healthcare databases and matching algorithms, healthcare providers can ensure more accurate and reliable patient identification, thereby improving overall data quality and patient outcomes.

The following excerpt illustrates minor spelling variations made when entering names and surnames and how a first name can be used as a middle name.

```
[ 'RAMOKONE', 'NTHONA' ]
[ 'RAMOKONE', 'PRINCESS', 'NKHONA' ]
[ 'Princess', 'Ramokone', 'Nkhona' ]
[ 'Ramokone', 'p', 'Nkhona' ]

[ 'GLENDA', 'MANTEPA', 'MAKGATHO' ] 'c692570e-fe08-11e8-98af-93b89c6d2b5e'
 [ 'GLENDA', 'MAKGATO' ] 'bc29bd6e-6665-11e9-927d-a70564543abf'
[ 'Glenda', 'mantepa', 'Makgatho' ] '1195a5fa-2bac-eae8-cbf3-3a0700b97042'
```

Figure 10-1:Problematic characteristics of human names

10.6 Handling Dates of Birth

Dates of Birth are an important criterion in matching, and it is assumed that most people know when they were born. Below is a graph by Statssa detailing the number of births per month in 2022. The data was taken from the Department of Home Affairs.

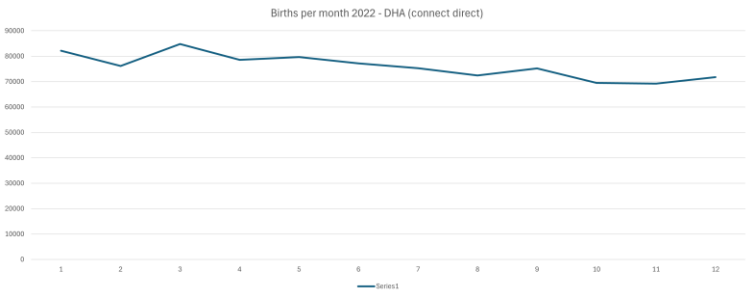

Figure 10-2: Sum of births per month for the year of 2022

https://www.statssa.gov.za/publications/P0305/P03052022.pdf

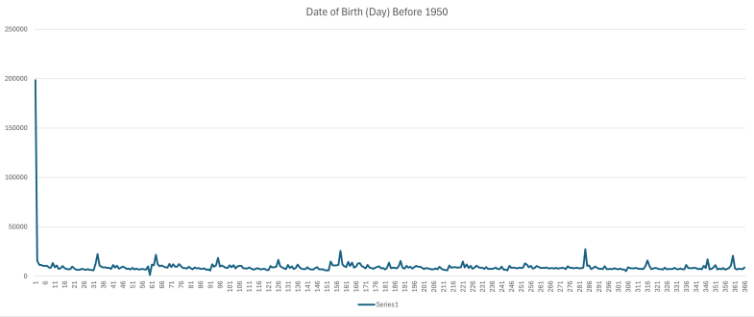

Figure 10-3: Sum HPRS births per day pre-1950

It is observed that there is a disproportionate peak of births registered on the first of January each year, with 200,000 registrations on that day compared to an average of 10,000 on all other days—20 times the typical daily registration.

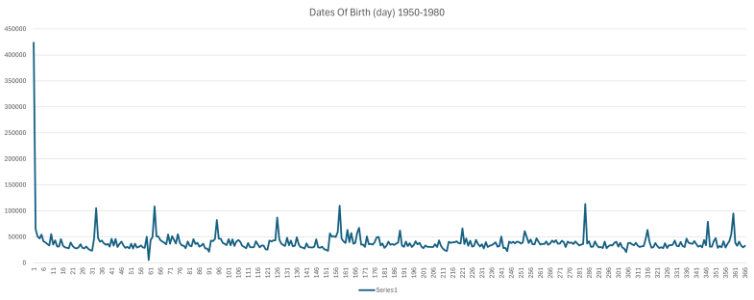

Figure 10-4: Sum of HPRS births per day 1950-1980

An analysis reveals a significant peak of 425,000 births registered on the first of January, which contrasts sharply with the average of 40,000 registrations per day on all other days—10 times the usual daily number.

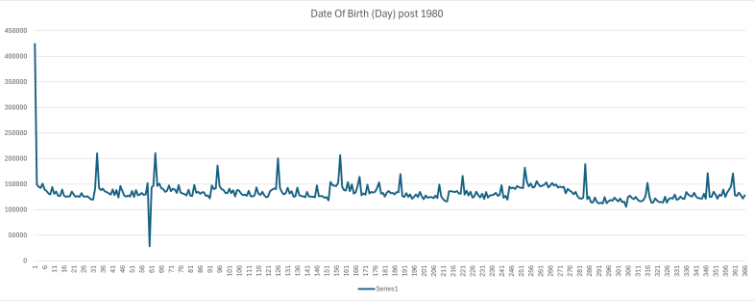

Figure 10-5: Sum of HPRS births per day from 1980 to present

Based on the data from South Africa, the observation that a disproportionate number of births are registered on January 1st each year can be substantiated by various sources. The high incidence of this particular date being used for birth registration is largely attributed to individuals who either do not know or cannot recall their exact date of birth. This is especially common among older populations in rural areas who may have less access to accurate record-keeping (Wong, Skead, Marchese et al., 2016).

In 2022, the Department of Home Affairs reported almost 1 million births registered, with a significant number being late registrations, which includes those assigning January 1st as the birth date. This pattern has been noted over several years, indicating that it is a longstanding issue rather than an anomaly (Department of Home Affairs, 2023; Statistics South Africa, 2022).

Moreover, studies suggest that the trend of using January 1st as a default date has declined over time. This shift could be attributed to the younger population, which is more connected and places greater importance on accurate documentation of personal details, reflecting an evolution in the socio-cultural approach to birth registration (Department of Home Affairs, 2023).

10.7 Matching Using Ambiguous Addresses

14 578 097 of 38 711 915 visiting patients (37.66%) provide addresses without a reference to any number (besides a postal code). We assume this is due to a lack of precise addressing for rural or informal living. This is supported by Coetzee and Cooper (2007, p. 457), who state that formal addresses have never been assigned to *vast areas of South Africa. These areas include farms, rural villages and former black townships.*

Coetzee and Cooper (2008) reference SANS 1883-1, which defines an address as an unambiguous specification of a point of service delivery. They emphasise the need for the standardisation of address format. Types of addresses listed by Coetzee & Cooper include street, intersection, landmark, building, site, farm, and informal dwelling. Few of these are precise and require a number for unambiguity.

This lack of precision in address data means that using an address to match most patients allows matching to a general area only rather than a precise location. 37.66% of the time, this matching will require extra criterion points. A more accurate and standardised means of referencing addresses is crucial for health service delivery (Coetzee & Cooper, 2007; Coetzee & Cooper, 2008).

10.8 Contact Details

The data indicates that out of 36,544,714 beneficiaries in the Health Patient Registration System (HPRS), only 20,083,946 listed a unique cellphone number. This implies that 55% of the listed cellphone numbers were unique, while 45% were shared between one or more individuals. The phenomenon of shared cellphone numbers is supported by McCrocklin (2021), who referenced a Pew Research Center study showing that 8% of South African adults share a phone with someone else, and only 5% do not own or share a phone (Perrin, 2021).

Beyond the sharing of numbers, several other factors contribute to the high percentage of duplicate cellphone numbers. Analysis revealed 16,671 instances where the same cellphone number was registered to more than 100 patients. This could be due to health staff entering their own phone numbers when patients prefer not to provide their own. Additionally, using autocomplete features to expedite registration may result in the same number being copied for multiple beneficiaries. It is also common for families to use a single number for all health communications, especially in low-resource settings where phone access may be limited.

These findings underscore the complexity of using cellphone numbers as a matching criterion for patient records. While a phone number is an essential data point, it must be used with other identifiers to achieve a high confidence match. Studies on digital literacy and phone usage patterns in developing countries suggest that shared phone usage is more common in lower-income and rural populations, where phones are often considered communal assets rather than individual

possessions (Gillwald, Moyo, & Stork, 2018). This communal approach to phone usage can complicate digital health initiatives that rely heavily on mobile communication.

10.9 Shared/Duplicate National Civil ID Numbers

The literature agrees that any ideal patient identifier must be unique and uniquely identify each patient (Neame, 1998; Omoro, Awuor, & Omamo, 2018). However, as the Department of Home Affairs (2012) has acknowledged, the national population register in South Africa is fraught with issues of duplicate civil identifiers. This includes cases where individuals have been assigned more than one identifier and instances where multiple citizens have been allocated the same identifier (Department of Home Affairs, 2012). These challenges undermine the effectiveness of the national civil ID as a reliable tool for patient identification in the healthcare system.

Analyzing data from the Health Patient Registration System (HPRS), it was found that 437,342 patients (1.34%) were registered with the same ID number but under different names, compared to other patients verified by the Department of Home Affairs. Notably, 24,290 of these cases involved identification documents that had been verified by healthcare staff. This suggests that relying solely on ID numbers for patient matching can result in multiple matches, complicating the identification process.

Furthermore, not all users of the South African health system possess national South African civil IDs, which further complicates patient identification.

Given these shortcomings, the South African national civil ID has clear challenges for use as a health identifier. The development and adoption of the Health Patient Registration Number (HPRN), a dedicated and unique identifier specifically designed for healthcare, aims to fill this gap (NDoH & CSIR, 2021). The HPRN is managed by the HPRS and is intended to provide a more reliable means of identifying patients within the health system, reducing the risks associated with duplicate or shared IDs.

10.10 Heuristics for Data Matching

To address the complexities associated with patient matching in the HPRS and ensure the reliability and accuracy of patient identification, this chapter proposes several heuristics derived from the literature and empirical data analysis. These heuristics serve as practical strategies to navigate the challenges posed by data inconsistencies, cultural variations in naming, and the presence of shared identifiers. By utilizing a combination of key identifiers such as first name, surname, date of birth, and sex, the likelihood of duplicate matches is significantly reduced. The chapter emphasizes the importance of integrating referential matching approaches that leverage verified reference data, such as that from the Department of Home Affairs, while remaining vigilant about potential discrepancies within the reference dataset. Additionally, the implementation of algorithms capable of handling special characters and name variations, as well as standardizing data entry protocols,

is critical for improving the accuracy of patient matching. Using unique identifiers, such as the Health Patient Registration Number (HPRN), and considering the role of family relationships in search algorithms further enhance the effectiveness of these heuristics in creating a robust patient identification system within South Africa's healthcare landscape.

The following are presented as Suggested Heuristics for Patient Matching in the Health Patient Registration System (HPRS)

- *Combination of Key Identifiers:*

Utilize a combination of key identifiers such as first name, surname, date of birth, and sex to enhance the precision of patient matching. Research suggests that combining these variables significantly reduces the likelihood of duplicate matches within the patient registry, thereby improving the accuracy of patient identification (Cummins, 2007).

- *Referential Matching Approach:*

Implement referential matching techniques by using verified reference data from authoritative sources like the Department of Home Affairs (DHA). This method has been shown to outperform traditional probabilistic matching in terms of accuracy. However, caution must be exercised to account for discrepancies within the reference datasets (Grannis et al., 2022).

- *Handling Special Characters and Name Variations:*

Develop algorithms capable of processing names with or without special characters and accents. This includes accounting for name order variations and using initials, which is crucial for accurately matching records in a multicultural context (Just et al., 2016).

- *Address Matching:*

Given the imprecision of address data in rural and informal settlements, avoid relying solely on addresses for patient matching. Instead, addresses should be used in conjunction with other identifiers to improve matching accuracy, acknowledging the need for more precise and standardised referencing of addresses (Coetzee & Cooper, 2008).

- *Consideration of Spelling Errors:*

Implement algorithms that accommodate minor spelling variations in names and surnames. This includes recognizing and matching names despite common typographical errors, thus enhancing the reliability of patient identification (Cummins, 2007).

- *Utilization of Unique Identifiers:*

Leverage unique identifiers such as the South African identification number or the Health Patient Registration Number (HPRN) to achieve more accurate matches. However, be aware of the challenges that shared or duplicate national civil ID numbers pose, which can complicate the matching process (Neame, 1998).

- *Handling Shared or Duplicate Contact Information:*

Recognise that cellphone numbers may be shared among multiple individuals, particularly in low-resource settings. Use cellphone numbers in conjunction with other identifiers to achieve a match of high confidence, considering the communal nature of phone usage in these contexts (McCrocklin, 2021).

- *Dealing with Ambiguous Birthdates:*

Address the common use of January 1st as a default birthdate for individuals who do not know their exact date of birth. This practice necessitates additional scrutiny when using birthdates as a matching criterion, particularly in populations with low birth registration accuracy (Wong et al., 2016).

- *Cultural Considerations in Naming:*

Incorporate cultural and linguistic diversity in naming conventions into matching algorithms. Understanding the occurrence of duplicate name and surname combinations within particular cultural contexts is essential for improving the accuracy of patient matching (De Klerk & Bosch, 1996).

Incorporating Family Relationships:

Utilize recorded family relationships, such as parent-child links, in search algorithms to enhance the identification of duplicate patients. This approach is beneficial in communities where children are named after grandparents or other relatives, adding another layer of complexity to patient matching (Makgopa & Rugwiji, 2021).

These heuristics form the foundation of a conceptual framework to improve patient matching within the HPRS, contributing to more accurate and reliable patient identification in South Africa's healthcare system.

10.11 Concluding Thoughts and Further Work

In conclusion, implementing heuristic approaches for patient matching within the Health Patient Registration System (HPRS) presents a viable pathway to improving the accuracy and reliability of patient identification in South Africa. By leveraging a combination of key identifiers, referential matching techniques, and culturally aware data handling methods, the proposed framework

addresses the significant challenges posed by data inconsistencies, shared identifiers, and the diverse cultural context of South Africa. Adopting these heuristics enhances the integrity of the national patient registry. It supports the broader goals of the National Health Insurance (NHI) in providing equitable healthcare access to all citizens and residents. Future research should continue to refine these heuristics and explore their application in other national health systems, ensuring that the lessons learned from South Africa can contribute to global efforts in health information management and patient safety.

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Chapter 11: Overview of an Electronic Health Record and an Electronic Medical Record to Support the Digital Health System in South Africa

Herselman, M.,[1]Rousseau, P.[2] and Botha, A.[1]

[1]Next Generation Enterprises and Institutions (NGEI) cluster, Council for Scientific and Industrial Research (CSIR), Pretoria, South Africa; [2]Digital Health Unit, National Department of Health, South Africa

Purpose: *This chapter provides an overview of the importance of developing an Electronic Health Record (EHR) and an Electronic Medical Record to support the Digital Health System in South Africa. Information on the topics will be provided to help understand these concepts' challenges, building blocks, design elements, and realities and how an EHR and EMR can enhance a digital health system.*

Methodology/Approach: A qualitative exploratory literature review defines and explains the concepts. Using this method, one can map the existing knowledge of the phenomena and identify gaps the studies address. Document and thematic analysis were used to examine and interpret data from the selected articles to uncover meaning, gain understanding, and conclude. Understanding the challenges, building blocks, design elements, and realities associated with an EHR and EMR will add to its applicability in South Africa.

Findings: *The value and use of EHR and EMR systems towards the South African Digital Health System were found to be invaluable. The difference between an EHR, EMR and Personal Health Record (PHR) was provided together with the advantages, challenges, adoption issues and implementation phase considerations. It was found that EHR and EMR systems can overcome challenges facing the South African public health sector in records management (duplicate, misfiled or missing files, illegal access and destruction of records, long waiting times to receive medical attention, limited human resources, poor handwriting and more). These systems can also realise an unprecedented advancement in healthcare quality, efficiency, and performance, as well as the discovery and evaluation of preventative care and treatments, including precision medicine. Challenges experienced with EHR systems include the lack of training, infrastructure, management commitment, standards, consistency, interoperability, quality of systems, support, use, information, satisfaction and impact of the system, confidentiality, integrity, authorisation, access control, portability, efficiency, security, scalability of solutions, and issues related to user experience.*

Originality/value: *Implementing electronic health records (EHR) can be seen as a sustainable method for this increased continuity of care. EHRs provide a centralised repository for collecting health information, thus creating an efficient communication pathway between patients and healthcare providers with a decrease in medical errors and an improvement in monitoring a patient's health status. It is essential to identify and locate a patient's health information, not only for reducing cost or administration purposes but also to ensure that the correct care is provided to the correct patients at all the various healthcare facilities they are attending. The consolidated view of one patient's data from various facilities or healthcare institutions is essential to providing better service delivery to every person.*

Keywords: *Electronic Health Record (EHR), Electronic Medical Record (EMR), Digital Health System, South Africa*

11.1 Introduction

It is becoming increasingly common for countries to provide universal health care; middle-income countries, in particular, are expanding this coverage with public funds. By improving the efficiency and accessibility of health services, digital interventions benefit both patients and providers (El-Jardali et al., 2023; WHO, 2021; Zharima et al., 2023). Public funds can be used more effectively by monitoring patient outcomes and provider performance via electronic health records (EHRs) (Cowie et al., 2017; Mehl & Labrique, 2014; Krzesiński, 2023). For low- and middle-income countries, the World Health Organisation suggests that investing in appropriate digital health solutions, such as EHRs, is essential, as it can improve healthcare delivery, improve cost-effectiveness, support the sustainability of health systems, and enable Universal Health Coverage (UHC) (WHO, 2021). Gatiti et al. (2021) support the WHO (2021) by indicating that EHRs can further support universal health coverage as these can enhance patient safety and ensure effective, efficient, timely, equitable, and patient-centred healthcare. The COVID-19 pandemic accelerated the adoption of digital health technologies across the globe, particularly telemedicine and electronic health records (EHRs), as health systems sought to maintain continuity of care while reducing in-person contact (Keesara, Jonas, & Schulman, 2020).

South Africa is moving towards National Health Insurance (NHI) when the NHI Act 20 (2023) was gazetted on 14 May 2024. This Act aims to achieve improved UHC for the South African population, in line with section 27 of the Constitution (RSA, 1996), which indicates that everyone has the right to access healthcare services, including reproductive health care, and no one may be refused emergency medical treatment. To achieve this, an EHR/EMR system can contribute to the digital health system by strengthening initiatives, addressing challenges in healthcare financing, and eliminating fragmentation in the health system (NDoH, 2019). Furthermore, authorised

healthcare providers use EHR systems to capture, store, and use patient information to provide healthcare services effectively (Muhaise et al., 2019).

This would assist in strengthening the under-resourced public sector by improving health system performance and increasing healthcare continuity (Lee et al., 2023; Sithole, 2015). Additionally, implementing electronic health records (EHR) can be seen as a sustainable method for this increased continuity of care (Gatiti et al., 2023). EHRs provide a centralised repository for collecting health information, thus creating an efficient communication pathway between patients and healthcare providers with a decrease in medical errors and an improvement in monitoring a patient's health status (Els & Cilliers, 2018; UNDP, 2024, January 29). It is essential to identify and locate a patient's health information, not only for reducing cost or administration purposes but also to ensure that the correct care is provided to the correct patient at all the healthcare facilities they are attending (Anshari, 2019). Overall, EHR systems, also known as electronic medical records (EMR), help healthcare organisations securely and digitally manage patient data, resulting in more coordinated patient care across the healthcare continuum (Witowski, 2024, February 01). The consolidated view of one patient's data from various facilities or healthcare institutions is essential to providing better service delivery to every person (Uslu & Stausberg, 2021).

The diversity in databases of health information systems can prevent interoperability (Ntafi et al., 2022). Different systems refer to the same person or have insufficient or incorrect information as it was misinterpreted upon data capturing (Zharima et al., 2023). The results are duplicate records, incoherence, suspension and dispersion in the data of patients, and this affects optimal service delivery across all the health facilities (Gatiti et al., 2021). A secure, inclusive, and responsible method of uniquely identifying and authenticating healthcare users over time and across facilities is central to these needs and the goal of achieving universal healthcare (WHO, 2021). The World Health Assembly (WHA, 2018) recognised the potential of digital technologies like EHR and EMR systems to advance the Sustainable Development Goals (SDGs) and adopted a resolution to leverage digital technologies for Universal Health Coverage (WHA, 2018). This is particularly true for SDG 3, which focuses on ensuring everyone's health and well-being. Despite the promising outlook, the realisation of these technologies' full potential in Africa is contingent upon addressing existing challenges in infrastructure and training (Ibeneme et al., 2022; Manyazewal et al., 2023; Manyazewal et al., 2021; van Stam, 2022). The South African Digital Health Strategy (NDoH, 2019), represents a significant step towards achieving this objective.

11.2 South Africa's Digital Health Strategy

The South African Digital Health Strategy (NDoH, 2019) emphasises critical components such as electronic health records, digitising health system processes, interoperability, mHealth for community interventions, and cultivating digital health knowledge workers. Its focus on governance, stakeholder engagement, and capacity development highlights a person-centred

approach, underpinning the drive towards innovation and sustainable impact within the digital health domain.

This comprehensive aims to align digital health interventions like developing the EHR and EMR with the country's health sector priorities, tackling the quadruple burden of disease, enhancing care quality, and supporting the transformation required for National Health Insurance (NHI). Importantly, it targets the fulfilment of Sustainable Development Goal (SDG) 3 by ensuring adequate coverage beyond service delivery to encompass effective treatment and patient outcome monitoring, necessitating robust electronic health records.

11.3 Methodology

This study will consist of a qualitative exploratory study reviewing relevant literature (Nor, 2020). Exploratory qualitative research identifies themes and patterns, generates hypotheses, and explores phenomena (Olukiun et al., 2021; Yadav, 2021). In investigating the phenomena, the researcher can leverage insights from authors in research papers (Prasantham, 2023; Ragab & Arisha, 2017). Using this method, one can map the existing knowledge of the phenomena and identify gaps the studies address (Fernandez, 2020; Olukiun et al., 2021; Prajapati et al., 2015). Document analysis will also examine examples of papers and identify best practices. Document analysis and thematic analysis will be conducted to discover and understand a phenomenon with themes generated from the review data (Sandelowski, 2010).

An analysis and discussion of the findings of this study will be conducted, including the original research problem and the literature that has already been published. Using this analytical process, meaningful insights are generated and practical and theoretical implications are defined (Abdulai & Owusu-Ansah, 2014; McMeekin et al., 2020).

11.4 Determining what is an Electronic Health Record (EHR)

An Electronic Health Record (EHR) provides each individual with a personal, secure and private lifetime record of their key health history and care within the health system (Uslu & Stausberg, 2021). The record is available electronically to authorised healthcare providers and, in selected instances, to the individual anywhere, anytime, in support of high-quality care to support healthcare-related activities and evidence-based medical decision support both directly or indirectly (Woldemariam & Jimma, 2023; Troshani & Wickramasinghe, 2016). 'The introduction of an electronic record should enable healthcare workers much greater access to timely, reliable and accurate data and significant gains are envisioned at the hospital interface, where quick access to a patient's clinical record could be lifesaving (Gatiti et al., 2021; Pullen & Al-Hakim, 2016). Information in EHRs is collected longitudinally during patient visits at any healthcare delivery setting (Blobel, 2018).

An EHR is also defined as an archive of a patient's clinical data processed by a computer (Lee et al., 2023). With many hospitals implementing EHRs and other IT systems, the amount of patient data stored in electronic formats continues to increase (Haan, Main & Watts, 2024, June 01; UNDP, 2024, January 29). This opens an easy and quick communication channel between two or more independent hospitals and clinics for sharing and accessing patients' records through a common medium (Kosteniuk et al., 2024).

According to ISO/TR 20514 (ISO, 2024:1), an EHR is "a repository of information regarding the health status of a subject of care in computer processable form". It provides the "ability to share patient health information between authorised users of the EHR and the primary role of the EHR in supporting continuing efficient and quality integrated health care". The exact ISO specification defines an EHR system as a "system for recording, retrieving and manipulating information in electronic health records", or – adapted from the Institute of Medicine's Computer-based Patient Record System (1997:35) definition, "a set of components that form the mechanism by which electronic health records are created, used, stored and retrieved including people, data, rules and procedures, processing and storage devices, and communication and support" facilities. There are different types of EHR depending on the viewpoint applied.

Tlali (2022, November 02) and UNDP (2024, January 29) further explain that EHRs are digital health records that include a patient's medical history, diagnoses, medications, treatment plans, immunisation dates, allergies, radiology images, and laboratory and test results. EHRs contain information from all clinicians involved in a patient's care; all authorised clinicians can access the record.

The EHR evolved from several electronic methods of storing patients' health data that became a structured and interoperable approach.

11.4.1 What is the Difference Between an HER, EMR and PHR?

Hospitals and clinics often use EMRs and EHRs to streamline clinical processes and keep doctors and nurses connected and updated with critical patient information. Although hospitals use both applications to store health information, maintain patient records and simplify several administrative workflows, these solutions have quite a significant number of differences (Sarkar, 2024, June 20). This is explained in the figure below:

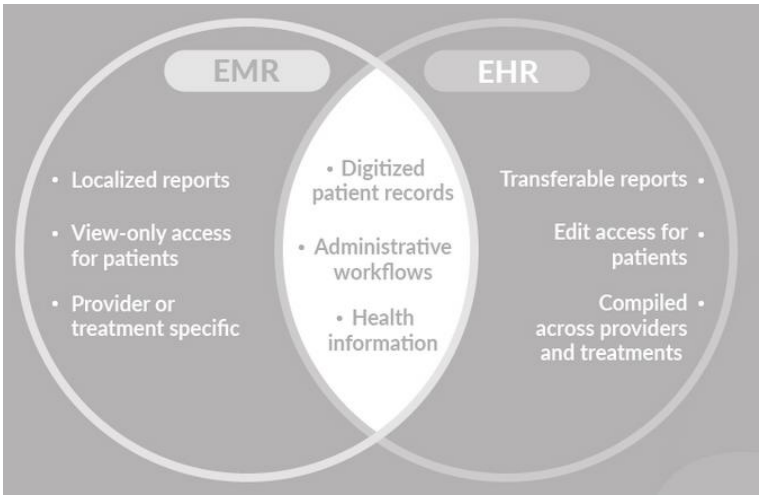

Figure 11-1: The Difference Between an EMR and an EHR (Adapted from Sarkar, 2024, June 20)

Although EMRs are digital versions of paper charts that offer a comprehensive view of patients' medical histories, EHRs provide a holistic overview of their overall health journey, including digital records across treatments and providers. In an EMR, patients can only view their data, whereas an EHR allows them to change records based on their role (eHealth Ontario, 2024; Sarkar, 2024, June 20; Risling, 2019, November 21).

To summarise, an EMR is used extensively by hospitals and clinics for internal record keeping. Though used widely, EMRs do have some limitations. For instance, only specific physicians can access the data stored in an EMR. Patients cannot move EMRs if they decide to switch hospitals or physicians. On the other hand, EHRs go beyond standard clinical data collection to promote interoperability and share information with other healthcare providers, such as laboratories and specialists, to provide a complete overview of a patient's health (Sarkar, 2024, June 20).

Many Organisation for Economic Co-operation and Development (OECD) countries use EMR and EHR interchangeably (Muhaise et al., 2023). In addition, the approach does not require or assume the use of a particular technology and should promote consistency over time, even as new technologies are introduced (Zelmer et al., 2017).

Table 11-1: The Difference Between EHR and EMR (Hersch, 2014; Sarkar, 2024, June 20; Haan et al., 2024, June 01; Tali, 2022, November 02)

EHR	EMR
It is used as the preferred term (Hersh, 2014).	It was used when electronic records were introduced.
EHR contains the patient's records from multiple doctors and provides a more holistic, long-term view of a patient's health. It includes their demographics, test results, medical history, present illness (HPI) history, and medications.	In the USA, an EMR is best understood as a digital version of a patient's chart. It contains the patient's medical and treatment history from one practice. Usually, this digital record stays in the doctor's office and is not shared. If a patient switches doctors, their EMR is unlikely to follow.

EHR	EMR
All digital records of patient health information	A digital version of a patient's chart
It goes wherever the patient goes and gets shared by healthcare providers. As an all-inclusive patient record, it can powerfully help improve patient care and health outcomes.	It is not designed to be shared outside the individual practice or point of care/services.
It gives clinicians access to a wider range of patient data than an EMR. Such access facilitates better-informed decision-making and care planning. It provides access to tools that providers can use for decision-making.	Providers mainly use it for diagnosis and treatment.
It meets meaningful use standards for incentive programs administered by the Centres for Medicare & Medicaid Services (CMS). This compliance is an important reason why the healthcare industry increasingly uses EHR systems.	

Both EMRs and EHRs help make healthcare more efficient and less costly. However, an EHR solution must go beyond basic clinical data and focus on each patient's health.

There is increasing interest in the *personal health record* (PHR), which usually refers to the patient-controlled aspect of the health record, which may or may not be tethered to one or more EHRs from healthcare delivery organisations.

11.4.2 The different types of EHRs

There are three types of EHR systems, including cloud-based, physician-hosted, and remotely-hosted EHRs (O'Connor, 2024, February 23). Each will now be discussed:

- Cloud-based EHR differs somewhat from mainstream applications. These tools must comply with HIPAA regulations to keep electronic medical records confidential and secure. As a result, cloud-based EHR has extra layers of protection to ensure that only authorised healthcare professionals can access resident data.
- Despite the name, physician-hosted EHR isn't limited to physicians. Under this traditional approach, all medical information gets stored in on-site servers owned by individual healthcare providers, senior living communities, or organisations.
- Remotely-hosted systems store data on third-party servers owned by EHR vendors. These solutions often use cloud-based storage, as discussed above. Other models include dedicated servers reserved for specific organisations and subsidised servers funded by the vendor.

There are pros and cons for each type of EHR system as provided in the table below:

Table 11-2: Pros and Cons of Each Type of EHR System (O'Connor, 2024, February 23; Sarkar, 2024, June 20)

EHR system type	Disadvantages	Advantages
Cloud-based	*Accessibility*: Authorised care providers can access resident information from any location and using any approved device. This feature provides greater flexibility because staff members don't need to rely on on-site computers.	*Internet Reliance:* You must be connected to the Internet to access and update EHR data. This limitation may make this type of system unreliable for organisations with unreliable internet access.
	Affordability: Many cloud-based EHR systems have low price points, so small practices and senior living communities with limited budgets can afford them. Plus, you won't need to hire IT professionals to maintain the software.	*Ongoing Expenses*: Typically, cloud-based services charge monthly usage fees.
	Increase Efficiency: Cloud storage allows senior living professionals to quickly share resident medical information with pharmacies, primary care clinics, and other healthcare organisations.	*Slow Upload Times*: Occasionally, you may experience upload delays for huge files.
	SaaS Features: Many cloud-based EHR solutions have additional Software as a Service (SAAS) features to streamline workflows. For instance, an EHR platform could have an integrated appointment scheduler and payment portal.	*Limited Customisation:* You might have fewer options to customise your EHR software to suit your organisation's unique needs, though some solutions are more flexible than others.
	Secure Storage: If a disaster strikes your senior living community, you can rest easy knowing that your residents' valuable data is securely stored off-site.	*Security Risks*: While cloud-based EHR is generally safe, every company must work to meet digital security requirements to ensure that their databases are secure.
Physician-based	*Infrequent Expenses:* You'll need to spend a significant amount of money upfront to buy servers and other equipment. However, you won't have to pay monthly data storage fees to external EHR vendors.	*Cost:* This system can be expensive because providers must purchase the technology and hire staff to maintain it. For this reason, physician-hosted software is mostly used by large healthcare organisations with big budgets.
	Greater Speed: On-premise servers can upload and share information marginally faster than remote servers.	*Downtime:* The organisation must periodically shut down the computer system for short periods to install updates, which can be inconvenient for staff.
	Increased Flexibility: You can choose the optimal combination of hardware and software to maximise functionality and interoperability.	*Ongoing Maintenance:* Health IT staff must actively monitor and maintain the system to protect residents' data.
	Retain Data Ownership: The organisation owns its medical data without interference from outside entities.	*Possible Data Loss:* If the organisation shuts down, residents might be unable to access and transfer their medical data.
Remotely-hosted	*Fast Start-up:* You can quickly start using remotely hosted EHR without installing complicated hardware and software.	*Internet Reliance:* Because data is stored off-site, you need to use the Internet to access it.

EHR system type	Disadvantages	Advantages
	Cost Savings: This system is less expensive than physician-hosted EHR software, so it's more affordable for small organisations.	*Loss of Data Ownership:* Organisations that use subsidised servers must surrender ownership of their medical data. This loss of control can lead to sticky legal situations.
	No Maintenance Responsibilities: The server owner handles all updates and security issues, saving healthcare organisations time and money.	*No Control Over Maintenance Schedule:* The external vendor updates the server on their own schedule, which may result in inconvenient downtimes.

11.4.3 Explaining a Personal Health Record (PHR)

A PHR is defined as health records related to patient care that the patient controls and represents a person's health information, wellness, and development (Roehrs et al., 2017). When you allow patients to have access to their health data, making them the owners of such data, personal health records (PHRs) emerge from the EHR, and the main advantages of the PHR refer to the ability of patients to maintain data on their health (Roehrs et al., 2017). Challenges need to be overcome to promote widespread PHR adoption, including how to achieve interoperability using the EHR, implementation costs, privacy, security, and the assessment of the effective benefits that the patient may have(Gold et al., 2017).

Although PHR may refer to records regardless of format (and can be on paper), the records are implemented electronically and accessible through mobile devices. In this sense, PHRs have allowed patients to self-monitor and manage their health conditions. Some variant names for PHR appeared in the literature, such as ePHR (electronic PHR) or UHR (universal health record) (Risling, 2019, November 21). The first concept refers to using PHR in an electronic format, while the second proposes PHR-sharing data with health care providers. Another term is intelligent PHR (iPHR), which uses medical knowledge to anticipate the health needs of patients and promote tools to guide searches for diseases and recommendations for nursing activities or medical products (Roehrs et al., 2017).

The advantages of using a PHR, according to Risling (2019, November, 21), include:

- As more health applications and tracking tools have become available on our computers or smartphones, many people have begun to gather their own data in personal health records (PHRs).
- For those managing an ongoing health concern or condition for themselves or a family member and those working on personal health goals, the PHR has become a valuable tool to track changes over time. A PHR allows patients to create their own single record for data gathered from many providers.

Several uses of PHR include (Els & Cilliers, 2018):

- Accessing Health Data*:* A patient can access available clinical records or view lab results;
- Obtaining Health Information: A patient can access protocol information or self-management information in a central knowledge base;
- Recording Personal Health Data: PHRs can be utilised to track and record subjective experience data or objective data related to a patient's condition over time;
- Receive Personal Decision Support: PHR data can create an initiative for evidence-based reminders and alerts for a patient, increasing self-management;
- Plan Care: A patient can proactively set personal goals and targets for their health care;
- Self-Manage Care: PHRs can be utilised in a patient's everyday decision-making about their care management;
- Communication with Care Team: Patients can engage with and support members of a circle of care, either virtually or face-to-face, through direct communication or data sharing and
- Communication with Support Group: Patients can utilise PHRs as a secure platform to engage with informal care teams or community members for support.
- PHRs can reduce medical errors and enhance the monitoring of health conditions (Risling, 2019, November 21).

11.5 The Advantages of EHR

The following advantages of using an EHR and conditions of use have been documented:

- EHR's advantage will increase when employees believe that an EHR has apparent effectiveness or cost-effectiveness over paper records and that an EHR can be easily implemented (Barrett, 2018; Lee et al., 2023).
- Msomi et al. (2021) endorse using an EHR system to overcome challenges facing the South African public health sector in records management. Common issues have been revealed, including misfiled or missing files, duplicate files, illegal access and destruction of records, long waiting times to receive medical attention, limited human resources, poor handwriting and more.
- Countries that develop EHR systems that combine or virtually link data to capture patients' healthcare histories have the potential to realise an unprecedented advancement in healthcare quality, efficiency and performance and the discovery and evaluation of preventative care and treatments, including precision medicine (Zharima et al., 2023).
- An EHR/EMR system can contribute to the digital health system by strengthening initiatives, addressing challenges in healthcare financing, and eliminating fragmentation in the health system (NDoH, 2019).
- The depth and breadth of such data in an EHR far exceeds that available from traditional

survey, administrative or research sources and supports new big data research techniques that can search for patterns and anomalies in populations (Oderkirk, 2017).

- Linking longitudinal EHR data to information about treatment costs and deaths, such data supports detecting unsafe healthcare practices and treatments, rewarding high-quality and efficient healthcare practices, and detecting fraud and waste in the healthcare system (OECD, 2013; Gatiti et al., 2021).
- When longitudinal EHR data can be linked to patients' behavioural, environmental, and biological (genetic) characteristics, such data then supports identifying optimal responders to treatment and personalised care for better patient outcomes and discovering and evaluating new healthcare treatments and practices. If such data is available for very large and representative patient populations, it can support selecting cohorts of patients for clinical trials and conducting long-term follow-up clinical trial cohorts (Hill et al., 2015; OECD, 2015).
- Generally, EHRs can improve administrative efficiency, data collection, and the quality of care. Linking fingerprints to EHRs can further eliminate the need to carry identification, reduce errors in record-keeping, and decrease the processing time and fewer duplicates, among other benefits (Gelb & Clark, 2013; eHealth Ontario, 2024). Furthermore, authorised healthcare providers use EHR systems to capture, store, and use patient information to provide healthcare services effectively (Muhaise et al., 2019).
- Biometrics can provide anonymity for patients; identifying someone via their fingerprint reduces the need for them to confirm personal details. Requiring healthcare providers to authenticate their transactions (prescriptions, treatments, etc.) can also help reduce fraud and improve accountability for both clinics and patients (Gelb & Clark, 2013; Anshari, 2019).
- EHR systems can be augmented with computerised physician order entry (CPOE), ePrescribing and decision support features (Masana & Muriithi, 2019).
- EHRs can provide staff with alerts for suggested corollary actions, potential drug interactions, and adjustment of drug doses, tasks that are poorly performed by human prescribers without aid. In addition, EHR systems have the potential to improve information and assist with monitoring of patient's health outcomes (eHealth Ontario, 2024).
- An EHR system allows for the capture of emergency department visits, information on allergies, hospital discharge summaries, home care and long-term care, infection control and reports on cardiovascular, diagnostic imaging (e.g. X-rays), neurophysiology, patient consultation, medical history, drug, lab outcomes, pharmacy service and mental health information, patient demographics, respiratory reports and visit or encounter details (eHealth Ontario, 2024).
- In rural primary care memory clinic teams, EMR/EHR platforms have contributed to

reducing role ambiguity and increasing autonomy. Ensuring team members contribute according to their scope of practice is crucial in enhancing autonomy and reducing conflict, as sharing increases opportunities for accountability and multivocality, allowing providers to construct the context of care (Kosteniuk et al., 2024).

- The National Academies of Sciences, Engineering, and Medicine (2022) highlights the best practices for implementing digital health technologies, including EHR systems, particularly in low- and middle-income countries. These practices emphasise the importance of stakeholder engagement, infrastructure readiness, and capacity building for successful implementation.

In summary, the following are important benefits and values of using an EHR (Uslu & Stausberg, 2021; Zharima et al., 2023; Kosteniuk et al., 2024):

- With fast, accurate and updated information, medical errors are reduced, and health care is improved;
- Patient charts are more enhanced, complete and more precise. It eliminates deciphering illegible scribbles;
- Information sharing can reduce duplicate testing, saving patients and providers time, money and trouble;
- Improved information access makes prescribing medication safer and more reliable;
- Promoting patient participation can encourage healthier lifestyles and more frequent use of preventative care;
- It adds to efficiency, accuracy, less fragmentation in health systems, and
- More complete information means more accurate diagnoses.

11.6 Challenges of EHR

The following challenges in using, adopting or implementing EHRs or EMRs are (Msomi et al., 2021; Woldemariam & Jimma, 2023; Roehrs et al., 2017; Kosteniuk et al., 2024; Zharima et al., 2023):

- Challenges are more focused on discussions regarding confidentiality, integrity, authorisation, access control, portability, efficiency, security, scalability of solutions, and issues related to user experience (Msomi et al., 2021; Roehrs et al., 2017; Kosteniuk et al., 2024).
- Concerns about managing change in the implementation process and developing a change management plan were considered challenging (Kosteniuk et al., 2024).
- Most of the challenges for the failure of EHR adoption were lack of training, infrastructure, management commitment, standards, consistency, interoperability, quality of systems,

support, use, information, satisfaction and impact of the system (Barrett, 2018; Woldemariam & Jimma, 2023; Kosteniuk et al., 2024).

- If health practitioners do not adopt an EHR or EMR system or experience it as a tedious extra workload, Zharima et al. (2023) indicate they will not use it or will be against using it effectively. Therefore, countries need to develop strategies, legislations, regulations, and a framework for implementation to address the mentioned challenges before adopting or implementing EHR systems (Barrett, 2018).
- With the continued advancement of EHRs, there is increasing concern that a potential loss of documentation integrity could lead to compromised patient care, care coordination, quality reporting and research, fraud, and abuse(Oderkirk, 2017).
- Poor system usability, including inappropriate EHR design, gets in the way of face-to-face interaction with patients and healthcare providers are forced to spend more time documenting required health information for the EHR (Lee et al., 2023). Features such as pop-up reminders, cumbersome menus and poor user interfaces can make EHRs far more time-consuming than paper charts (Sarkar, 2024, June 20). Poor system interface problems also can lead to poor decisions. For example, a laboratory value may return with an extra character inadvertently inserted (Vimalachandrandran et al., 2016).
- Inappropriate use of EHR can also result in potential data integrity issues. For example, copying and pasting or cloning can lead to redundant and inaccurate EHR information in EHRs. This feature can cause authorship integrity issues since documentation cannot be tracked to the source (Zelmer et al., 2017; Uslu & Stausberg, 2021).
- Functionalities added to assist with documentation capture (templates, standard phrases, etc.) can lead to inaccurate documentation and potentially result in medical errors or allegations of fraud, especially when misused, without proper education and controls (Gatiti et al., 2021). For example, clinical values are brought in from other parts of the electronic record (Wang et al., 2016).
- EHR's advantages and implementation must be accurate, timely, and efficiently communicated to employees. The benefits underlying EHR must be stressed to employees early in the implementation process, and organisations need to be honest about what the EHR system can achieve and what roadblocks likely lie ahead (Barrett, 2018).
- Privacy and security (Els & Cilliers, 2018): Privacy is essential to governing a patient-physician relationship, as patients must share information to facilitate a correct diagnosis and treatment. The benefits of privacy for patients include avoiding exploitation or embarrassment. Examples of such situations include identity theft, fraud, blackmail, discrimination and harassment. As such, they exemplify exploitations by identity thieves, employers, health insurance companies and even governments (Sarkar, 2024, June 20). Furthermore, sharing a patient's personal information may only occur within the limitations specified by the patient. Shuaib et al. (2022) suggest using blockchain technology to

improve efficiency, security and privacy.

- Downtime: EHRs face considerable downtime due to their over-dependency on computer systems. Power outages and program maintenance can cause downtime that may last weeks or months (Sarkar, 2024, June 20).
- EHR adoption policies currently missing in many countries can support this (Zharima et al., 2023).
- The staff's abilities to use technology like an EHR or EMR system differ. While some team members had the necessary skills to work comfortably with EMR/EHR platforms, others drew on colleagues' knowledge. For instance, a lack of proficiency in critical tasks was a barrier to care coordination and staff turnover (Kosteniuk et al., 2024).

11.7 Adopting EHR and EMR Systems

Linking to the challenges and advantages mentioned above, awareness of the following is necessary for the adoption of EHR systems (Woldemariam & Jimma, 2023):

Table 11-3: Barriers and Facilitators for EHR Adoption (Woldemariam & Jimma, 2023)

System factors	Barriers	Facilitators
People	Awareness, experience, resistance, lack of training	Providing alerts Perception to use EHR
Environmental	Interoperability with other systems, finance, absence of explicit policy, lack of standards, lack of management commitment, quality of a system	Immaturity of health information exchange infrastructure
Tools	Poor infrastructure	
Tasks		The partnership among stakeholders in designing and adopting EHR systems facilitates adoption.
Interaction between people, environments, tools and tasks	Poor integration of the EHR system with people, infrastructure, functions and other existing systems leads to poor adoption of these systems.	

The WHO recommended that developing countries establish *multi-stakeholder steering committees* to help determine what is available in their country and undertake suitable planning and development processes (Zharima et al., 2023). Modise, Matavera and Jantjies (2019) support the above and provide the following additional recommendations to maximise the adoption of EHR and EMR systems in healthcare facilities in South Africa:

- Involvement of Staff: Management needs to interact with their staff before proposing upgrades or new implementations, particularly staff that utilises the EHR system daily, as these users have in-depth knowledge of any pitfalls the system they work with may have

when it comes to their work. This form of involvement and transparency in the workplace decreases resistance and has increased productivity levels and other workplace and worker characteristics. Staff are also positioned to provide insights that could assist in *designing, testing and customising* the proposed system and its workflow (Jeffrey, 2016). Staff can also be utilised to provide feedback on their daily usage to aid in the optimisation and modification of the proposed system and workflow.

- System Functionality and User Interfaces: Ensure that the systems being procured provide functionality relevant to the staff's job functions, produce results that align with management expectations, and ensure that benefits that arise from using the system are clear to the user.
- Change Management: Change Management is defined as continually renewing an organisation's direction, structure, and capabilities to serve its customers' ever-changing needs (Woldemariam & Jimma, 2023). As part of the change management plan, training is one of the most popular interventions to increase the ease of use of a system. Training introduces the new technology users to how the new system looks and functions. This helps reduce the view the target group may have regarding the system's complexity.
- Creating and Hiring Digital Natives (Train-the-trainer): Seeing how the use of technology is increasing in the healthcare sector, it follows that healthcare facilities must ensure that their staff are familiar with the role computers play in their lives. Training courses on end-user computing are widely available in South Africa, which staff members with no computing experience can be made to attend. The integration of introductory computing courses in the curriculum of students pursuing careers in the healthcare sector could also add to maximising their efficacy and playfulness around computers.

The next section focuses on the interoperability of EHR systems.

11.8 Interoperability Levels of EHR

Zharima et al. (2023) indicate that many middle-income countries like South Africa have struggled with interoperability after implementing various digital health information systems like an EHR or EMR. The lack of interoperability is a recurrent theme in literature and has negative implications for care continuity in primary care. Interprofessional teams can be exacerbated when members regulated by different organisations use profession-specific platforms or work in multiple settings that use different EMR/ EHR platforms (Kosteniuk et al., 2024).

Interoperability is a prime driver that focuses on the benefits of EHR systems. Benefits rely on access to information regardless of place and time. Local, closed ICT systems lacking interoperability would not release the substantial gains alluded to above. Interoperable EHRs are the foundations of health information systems and support other systems, such as ePrescribing, eBooking, management, and administrative or logistics systems (Uslu & Strausberg, 2021).

Neither could realise their full potential without interoperability between EHRs and other clinical and non-clinical systems (Dobrev et al., 2009; Torab-Miandoab, 2023).

EHR interoperability levels, according to Nan and Xu (2023) and Lee et al. (2023), are:

- Potential interoperability involves EHR solutions and the use of technology standards allowing information to be shared, but without actual exchange taking place;
- Limited connectivity refers to a situation in which not all features and levels of interoperability, as defined above, are achieved, yet some information exchange and sharing is practised, and
- Extended actual connectivity comes close to real interoperation by using interoperability to exchange and share information and knowledge with other actors in the health system. This facilitates collaboration and change in clinical and working practices and roles, creating and expanding multi-disciplinary teams.

Distinguishing between the three levels stresses where benefits are related only to actual information sharing and exchange, not the mere potential. A further step in classifying interoperability is the range of connectivity, which enables the identification and transfer of lessons learned to other operational and proposed EHR initiatives (Ntafi et al., 2022).

In their study, Zharima et al. (2023) interviewed key South African role players on the challenges and facilitators of EHR implementation in South Africa and found that cloud-based EHRs (as explained in Table 11-3) may offer a solution to data storage problems with lower costs, greater reliability of power supply, ability to facilitate much faster interoperability and greater analytical computing power.

11.9 Key Architectural Principles and Decisions

Key architectural principles to consider when developing an EHR are the following (eHealth Ontario, 2024; Rinty et al., 2022):

- Integration, interoperability and reusability: systems will be constructed with methods that substantially improve interoperability and the reusability of components. Components will be purpose-built to support integration and rapid adaptation and are designed using service-oriented architecture concepts and methods, providing persistent and stable EHR capabilities while allowing for flexibility in the selection of new products and services and the repurposing of existing solutions to maximise value and minimise costs and components must be replaceable with minimal impact on existing users.
- Standards and open systems: information and technology standards provide the foundation for long-term stability and interoperability. Design choices should be prioritised toward open systems and creating adaptable, flexible, and interoperable, vendor-neutral solutions (Shuaib et al., 2022).

- Availability, scalability, reliability, and maintainability: To ensure the high availability of EHR information and services, reliability and availability must be part of the design. EHR components and systems must be scalable in size, capacity, and functionality to meet changing business and technical requirements and to minimise the application and platform changes required to respond to increased or decreased demand.
- Mainstream solutions: production IT solutions used in the EHR should use industry-proven, mainstream technologies except in those areas where advanced higher-risk solutions provide a substantial benefit.
- Privacy and security: EHR components should be built and/or procured to comply with the privacy and security requirements defined in South Africa's laws (POPIA) to employ adequate safeguards to protect the information they contain and the services they provide and to defend against the broadest possible range of vulnerabilities.
- Service-oriented architecture: EHR solutions should be designed using service-oriented architecture principles, enabling reusability to be leveraged or extended.
- Technological and operational convergence: EHR solutions should be designed with lower operational complexity regarding technology, process, systems, and operations to ensure higher stability, reduced cost, and enhanced delivery and operational capabilities.
- Leverage centres of expertise and build from success: promote the use of best practices and reuse of available artefacts, components, services, and processes.
- Provide multiple ways to interact with services: for example, interaction with EHR services may be provided through portlets in a portal, web services, and other means, including mobile devices.
- Support versioning and migration: service interfaces are based on standards and long-standing business processes; however, even the most solid standards change over time.
- Standards used in their EHRs
- The use of international standards is high for diagnosis, medicines, laboratory tests and medical images (Oderkirk, 2017; OECD, 2015; Shuaib et al., 2022).
- For diagnosis, twenty-six countries indicated that they were using the World Health Organisation's International Statistical Classification of Diseases and Related Health Problems (ICD) revision 10 or, in some cases, revision 9; and six countries reported the Systematised Nomenclature of Medicine -- Clinical Terms (SNOMED CT).
- For medicines, thirteen countries indicated using the World Health Organisation's Anatomical-Therapeutical-Chemical Classification (ATC) and SNOMED CT.
- Laboratory tests: Thirteen countries reported the Logical Observation Identifiers Names and Codes (LOINC) standard and SNOMED CT (OECD, 2015).
- Sharing medical images: The Digital Imaging and Communications in Medicine (DICOM)

standard is usually used for sharing medical images, as well as SNOMED CT. There is much less convergence toward a common standard for surgical procedures.

- Classification of surgical procedures: Seven European countries reported ICD 9 or 10; six countries reported the NOMESCO (NCSP); and five countries reported SNOMED CT (OECD, 2015).

11.9.1 African countries and the standards they apply

Standards that apply to African countries include:

For implementing semantic interoperability, the following were recommended (Mamuye et al., 2022):

- Kenya applies a standard concept dictionary based on the Columbia International eHealth Laboratory and the Millennium Villages Project (CIEL/MVP dictionary) (Keny et al., 2015). Kenya enabled data interoperability by using Application Programming Interface (API)–Extensible Markup Language (XML) (Oluoch et al., 2015).
- For Ghana, Damoah et al. (2014) explored the feasibility of HL7–XML in designing a centralised medical informatics system.
- For Botswana, Ndlovu et al. (2016) recommended the European eHealth Interoperability Framework (EIF) and the Australian eHealth Interoperability Framework. Similarly, Brenas et al. (2017) proposed SIEMA architecture and Web services to improve data and semantic interoperability for a malaria surveillance system.
- In Tanzania, data exchange components (DEC) recommended the realisation of interoperability of EHRs (Chali, Yonah and Kalegele, 2017). They are a leading African country implementing advanced health information exchange, has set strategic initiatives to leverage digital health technologies (Nsaghurwe, 2019). The initiatives included finalising the Tanzania Health Enterprise Architecture, strengthening technology standards (ICD-10, HL7, DICOM, LOINC, and services codes), and sharing client health records and health facility registers. In addition, designing a national eHealth standards framework and governance framework for enterprise architecture were two of the 17 investment recommendations prioritised by the government of Tanzania to improve health system performance through better data use.
- For Namibia, Angula, Dlodlo and Mtshali (2019) proposed IHE and HL7, Enterprise Master Index, JavaScript Object Notation (JSON), Internet Control Message (ICMP) and Internet protocols for semantic interoperability.
- For Ethiopia, Kenya, Malawi and South Africa, Baskaya et al. (2019) discussed how Health Level Seven Fast Healthcare Interoperability Resources (HL7 FHIR) based interoperability supported standards-based data exchange and interoperability between EMRs and DHIS2.

- eHealth strategies of African countries like Ethiopia, Liberia, South Africa, Tanzania, Uganda and Zambia included interoperability standards and health information architectures as a key priority (Mamuye et al., 2022).
- Zambia fostered health system integration through the following strategies: developing a master facility file, electronic master patient index and International Standard protocols (HL7, ICD-10, International Classification of Primary Care (ICPC2), SNOMED and LOINC) and local standards from Zambia Information and Communications Technology Authority (ZICTA) (Ministry of Health Zambia, 2017).
- Basic standards for Ethiopia's eHealth architecture were syntactic and semantic (such as ICD-10, LOINC, RxNorm, and SNOMED) (Federal Ministry of Health Ethiopia, 2017). Additionally, shared services such as the Health worker registry, Master Facility Registry and National Health Data Dictionary (NHDD) to map the National Classification of Disease (NCoD) with ICD 10 were described in the architecture to support interoperability (Federal Ministry of Health Ethiopia, 2017).
- Liberia used HL7 FHIR, Aggregate Data Exchange (ADX), CSD, and ICD-10 as relevant standards (Wu, Biondic & Cullen, 2016).

11.9.2 Standard for South Africa (HNSF)

The South Africa National Health Normative Standards Framework (NDoH, 2021) for interoperability sets a foundational base for interoperability. In this strategic document, the following was indicated for each type of standard:

- Content standards (HL7 Clinical Document Architecture (CDA) and Continuity of Care Document (CCD);
- Identifier standards (International Standard Organization (ISO) 22220:2011 and ISO/TS 27527 (2010);
- Messaging standards (HL7 V2.X, Digital Imaging and Communications in Medicine (DICOM), Statistical Data and Metadata eXchange Data Management (SDMX-DM);
- Terminology standards (International Classification of Diseases (ICD)-10);
- Procedure codes, medicine codes (Logical Observation Identifiers Names and Codes (LOINC) and Uniform Patient Fee Schedule (UPFS);
- Content and structure standards (American Society Of Testing Materials (ASTM)/HL7 CCD, HL7 3 CDA, HL7 CRS);
- Electronic health record standards (ISO/TR 20514:2005);
- Health-specific security standards (ISO/TS 22600–1:2006, ISO/TS 22600–2:2006);
- General standards and healthcare standards use ISO/TS 22600–3:2009.

11.10 EHR Implementation

- It is vital to plan for the implementation of EHRs. Such a plan is critical to ensure interoperability, confidentiality, availability, and integrity of patient health information data and timely, accurate, and regulatory compliance reporting (Gupta, 2023, March 01). It primarily consists of (Aquirre et al., 2019):
- Assessing existing institutional workflows for each department.
- It outlines the necessities and inclinations of the institution to include in the EHR system for the organisation to function correctly.
- Resources and tools are included to assist in training staff and evaluating staff readiness.
- Regulatory requirements are essential to consider during the initial process.

Linking to implementation is the phase of developing an EHR. The following phases in the development of an EHR are provided by Myshin (2023, September 25):

- Assessment planning.
- User-centred design.
- Data security and compliance.
- Interoperability integration.
- Database design and architecture.
- Development and testing.
- Mobile integration.
- Telemedicine integration.
- Training and implementation.
- Data analysis and reporting.
- User feedback and improvement.

Implementation focuses on people, processes and technology and happens in three phases (Aquirre et al., 2019; Luz et al., 2021): pre-implementation, implementation and post-implementation. Organisations must engage in extensive planning, stakeholder alignment, and training during the pre-implementation phase. The implementation phase focuses on executing technical and workflow changes, while the post-implementation phase emphasises system optimisation, user feedback, and ongoing training to ensure sustainability and improved outcomes (Tsai et al., 2020).

11.10.1 Pre-implementation phase

The pre-implementation phase determines the success or failure, as it is challenging to return to this phase once an EHR implementation begins. In this phase, it is crucial to focus on governance,

project management, managing attitudes, addressing data integration and attending to usability factors. According to eHealth Ontario (2024), a readiness assessment is also essential. This phase focuses on governance, project management and leadership, managing attitudes, assessing preparedness and addressing barriers.

11.10.1.1 Governance (People)

Governance has frequently been cited as necessary for IT project success and other IT deployment and use in organisations (Gatiti et al., 2021; Rinty et al., 2022; Woldemariam & Jimma, 2023). Governance refers to senior management's activities or substantive personal interventions in EHR implementation (Keshavjee et al., 2006). It is concerned with the mission, vision, and behaviours of top management related to pre-implementation, implementation, and post-implementation of the EHR (Woldemariam & Jimma, 2023).

The EHR plays a critical role in achieving the organisation's missions and visions (Kruse et al., 2016; Kosteniuk et al., 2024). Organisational support from the top is one of the most dominant factors associated with the successful implementation of EHR. Top management's commitment helps ensure adequate resource allocation, supports redesign efforts and facilitates implementation steps (Aquirre et al., 2019; Zharima et al., 2023).

11.10.1.2 Project Management Leadership (People)

Project leadership encompasses two roles: a project manager with skills and experience managing complex project implementations and a project champion with organisational credibility with clinicians (Aquirre et al., 2019). At the outset of EHR implementation, it is essential to define the roles and responsibilities of the project champions and the project managers and select the right people for these critical roles. The project champions' and managers' destiny is to bridge top management and other stakeholders (Keshavjee et al., 2006). The successful project manager should be able to plan, motivate, create an agreeable working climate, solve conflicts, negotiate with external contacts, coordinate and integrate and enhance internal communication. Forming an EHR committee is essential to set up realistic project management processes (Keshavjee et al., 2006).

11.10.1.3 Sell benefits, manage attitudes, assessment of preparedness and address barriers (Process)

Before implementing and installing an EHR, the organisation's readiness for the EMR must be analysed (WHO, 2021; Canada Health Infoway, 2011; eHealth Ontario, 2024). The organisation must be prepared for change by identifying core values, understanding broader organisational contexts and stakeholder concerns, understanding end-user needs, creating a vision and compelling need for change, and being sensitive and responsive to organisational stress resulting from change. In the meantime, demonstrating the benefits to the physicians, nurses, and staff, addressing the

obstacles and barriers that prevent buy-in, developing solutions to these potential problems, and providing quick wins can facilitate the success of change management (eHealth Ontario, 2024). Under 12.7, the issue of change management and having a plan is essential before implementation. EHR implementation causes physician fatigue due to contributing factors like increased workload, which are significantly underestimated (Muhaise et al., 2019; Kosteniuk et al., 2024).

11.10.1.4 Involve multiple stakeholders (People)

Involving multiple stakeholders meaningfully means gaining active participation and endorsement in the pre-implementation and implementation phases (Keshavjee et al., 2006). User resistance to change and lower user acceptance by physicians and nurses are among the main factors of failure (Woldemariam & Jimma, 2023). Implementations fail because implementers make assumptions about user requirements not shared by end-users, and those implementations that enjoy broad-based stakeholder support are less risky and more likely to succeed (Lee et al., 2023). An active role of multiple stakeholders during decision-making in these phases can facilitate the end-user acceptance of the new system (Aquirre et al., 2019). For this reason, the WHO recommended establishing stakeholder steering committees to help determine what is available in their country and undertake suitable planning and development processes (Zharima et al., 2023). Determining all stakeholder needs and requirements actively with any system redesign efforts is critical to success (see Table 11-4).

11.10.1.5 Data and Integration (Technology)

Integrating an EHR with other information systems containing billing, lab reporting, scheduling, diagnostic imaging and referral data allows an EHR to operate effectively (. Integration provides access to existing data and increases data accuracy and system efficiency. Another critical factor for successful implementation is creating a strategy for entering the practice's old data. The practical benefit of entering past paper-based or electronic data is the ability to rapidly search and retrieve the actual data, which reduces the frequency and duration of transitions between paper and electronic records (Gupta, 2023, March 01).

The real value of an EHR system is seen when all users have access to data whenever and where they need it (Uslu & Stausberg, 2021). In these terms, data and integration are inseparable points of EHR implementation. The most significant problems with loading data and ensuring integration are standardisation, interoperability between different systems, and workflow fit between EMR and other legacy systems (Keshavjee et al., 2006).

11.10.1.6 Technology usability factors (Technology)

Technology usability factors fall into hardware and software domains (Aquirre et al., 2019). Hardware usability speaks to structural issues such as placement of workstations, use of tablets, and other form factors that fit into clinician workflows, such as processing speed. Software usability speaks to user interfaces and how software design supports clinical workflows and work processes.

One of the main problems faced in EHR systems is that they are challenging to use because of the diversity of screens, options, and navigational aids (Gupta, 2023 March 01). Problems with EMR usability cause physicians to spend extra time learning effective ways to use the EMR. Steep learning curves can degrade already highly efficient and focused workflow, as was already discussed under the challenges of using an EHR system (section 12.6).

For the success of EHR systems implementations, technology usability is critical for overall system design, including hardware and software usability (Aquirre et al., 2019).

Msomi et al. (2021) posit that a change management strategy in EHR system execution is necessary for positive outcomes for system users. The evidence shows that choosing a change management approach that is not customised to the specific context of the EHR system implementation could hinder the progress of operating to the exceptional benefit of the hospital as system upgrades and advancement conspire to improve the system for its users (Muhaise et al., 2019). Msomi et al. (2021) recommend that the hospital develop its own change management framework to implement an EHR system that will include formal monitoring and evaluation of the process in the hospital. It is suggested by Msomi et al. (2021) that the NDoH in South Africa should establish an external monitoring and evaluation committee focusing on the implementation of EHR systems, consisting of peer reviewers from different branches so that those who are knowledgeable about information systems can evaluate the process used by vendors in preparing the hospital for any forthcoming technology implementation.

11.10.2 Implementation phase

In the Implementation Phase, the work of EHR activation begins. This is the actual test of an organisation's preparations made in the Pre-implementation Phase and of the overall match of these success factors to the nature of its EHR implementation (Keshavjee et al., 2006). This phase focuses on workflow and redesign, training implementation assistance, support, feedback and dialogue and privacy and confidentiality.

11.10.2.1 Workflow and redesign

Computer use, interconnectivity, and access to medical information worldwide have dramatically changed how physicians utilise technology (Keshavjee et al., 2006). Critical to successful

implementation is the fit of staff and physician workflow to that of the EMR functional and usability design constrictions or flexibility. EHR is a tool to automate and facilitate the process of patient care. Understanding the patient care process will be crucial in successfully transitioning to EHR (Aquirre et al., 2019).

11.10.2.2 Training

Familiarisation and training of primary users on the EMR should be initial and ongoing. Proper training is one of the key success factors for a smooth transition to a paperless patient care system (Kosteniuk et al., 2024). Hands-on training immediately before going live has been documented to be significant as the training is fresh in users' minds (Lee et al., 2023). Vendors of EMR systems should also ensure that training is provided in the language of novice users (Aquirre et al., 2019). Management should also be aware that ongoing training is just as essential as initial training provided by the vendor (Keshavjee et al., 2006). This is also highlighted as a critical aspect in Table 11-5 under capacity development.

11.10.2.3 Implementation assistance

Any successful implementation requires a strong vendor partnership. The vendor should be responsive, and the system should be flexible enough to allow any system improvements or modifications identified by clinicians or primary users (Gupta, 2023, March 01).

The assistance of a support and maintenance team can also ensure the adoption of the EHR system during implementation (Woldemariam & Jimma, 2023). Efforts should be made to detect, solve and follow up on problems that arise during implementation. The help desk must provide rapid and efficient service, or clinical users will stop calling and find another way to access and record data (Aquirre et al., 2019). Alternatively, a person should be available, preferably within the practice, to handle hardware and software problems and communicate with the vendor (Keshavjee et al., 2006).

11.10.2.4 Feedback and Dialogue

Providing a forum to discuss change and negotiate changing roles is critical, as initial success in EMR implementation often depends on how the considerable change management stresses are dealt with (Aquirre et al., 2019). Helpful interventions or activities include but are not limited to the following (Aquirre et al., 2019):

- Regular staff meetings.
- Opportunities for discussion and venting. This requires a thick skin on the part of the administrator, but vigorous criticism can have value for prospective change.
- Evaluation, monitoring and tracking of the progress of implementation. This is especially valuable if the EMR is deployed modularly. In this way, the gap between design and reality

can be recognised and minimised, thus reducing the extent and stress of change.

- Systems to track issues and problems with a process to resolve them. Recognising that there are both technical and social aspects at work in EHR implementation, it must be seen that the technology and the organisation transform each other during the process. Even with a well-planned implementation, the process can take on a life of its own, and a flexible system is essential.

11.10.2.5 Privacy and confidentiality

EHR implementations must meet privacy and confidentiality requirements as discussed in sections 1.4.3, 1.6 and 1.7). The ideal record system will provide appropriate and non-intrusive access while demonstrating robust data security. Physician and patient concerns regarding security must be addressed, especially for Web-based records (Sarkar, 2024, June 20). EHR privacy and confidentiality should be equal to that of paper record systems. Minimising the risk of inappropriate data acquisition and transfer is critical to health data integrity and its use (Shuaib et al., 2022). This needs to be done through education concerning the appropriateness of transmission, access control, system integrity, network security, clear data ownership, user profiles and audit trails (Aquirre et al., 2019). Participants in a study on EHR implementation in South Africa (Zharima et al., 2023) highlighted the challenge of data storage and how the health department needs a central data repository essential for successfully integrating health information systems. Concerns about data protection and cyber security can be met by ensuring that the servers providing the cloud-based services are located in a jurisdiction with at least the same, but preferably stronger, regulation of such issues (Zharima et al., 2023).

11.10.3 Post-Implementation phase

After extensive planning in the pre-implementation phase and the activities characterising the implementation phase, the post-implementation phase may seem less intensive. However, this phase is equally essential for the overall success of an EHR implementation (Aquirre et al., 2019). The elements characterising this phase also encompass the people, process and technology axis. This implementation stage also has the same dynamic interaction of negotiation and dialogue in the earlier phases. Post-implementation user involvement to foster value, training, support, and system enhancements is vital to providing incentives for continued user involvement and buy-in and sustaining the positive momentum of a previously well-planned and executed implementation.

11.10.3.1 Technical and skills development support and business continuity

As a first step to ensure that post-implementation activities can proceed, it is necessary, with vendor contractual agreements in place, to ensure that technical support for both newly installed hardware and software remains available and accessible on time (Keshavjee et al., 2006). There must also be a business continuity plan that provides data protection and disaster recovery.

11.10.3.2 User groups

A critical factor in post-implementation is a structured format, such as scheduled meetings or user groups led by EHR champions with a process to help users accept and grow in using the new technology in their work (Aquirre et al., 2019). This interaction provides a forum for ongoing training and facilitates a cooperative dynamic where one can solve technical problems, write templates, and teach each other about software features (Keshavjee et al., 2006).

In summary, the operative features in the post-implementation phase are extensions of those seen in the implementation phase as discussed under the implementation assistance, feedback and dialogue success factors. The emphasis is on sustainability through the continuation of solid vendor partnerships and quality improvement via user feedback processes, followed by added value with the expansion of capabilities in patient care (e.g., recall systems, e-prescribing, clinical decision support systems, chronic disease management, etc.) that provide further incentives to promote full integration of the EMR into the health delivery system of an organisation.

Several factors affect the implementation of EHR systems, as outlined below.

Table 11-4: Factors influencing the implementation of an EHR (Zharima et al., 2023)

Factor	Details
Leadership	Use leaders who understand the scale of implementation and obtain buy-in from various stakeholders for a collaborative implementation process. Leadership appointments should be based on merit rather than political affiliations. Internal conflicts lead to uncertainty and hinder progress.
Skills and expertise	Capacity building to address a skills shortage in the public health sector and collaborating with more skilled sectors can be helpful. Healthcare workers should be involved in the implementation process. Early training programs can prepare the healthcare workforce for implementation.
Resources, funding and infrastructure	Long-term investments towards infrastructural needs (hardware, connectivity, etc.). Increase funding for public health facilities in remote areas. Set up data storage centres to facilitate the integration and migration of health data. Build on existing infrastructure while gradually upscaling.
Governance	Align provincial and national health departments for concerted implementation. Better monitoring mechanisms for tender systems to combat corruption and improve accountability are necessary. Appoint appropriately qualified and skilled authorities to prioritise digital health. Have a transparent and multi-disciplinary panel of experts to help with planning and decision-making.

11.11 Measuring the Maturity of Electronic Record Adoption

Maturity models have become ubiquitous tools across various domains, serving as frameworks for assessing the progress and capabilities of individuals, teams, and organisations. These models provide a structured roadmap for understanding current performance, identifying areas for improvement, and driving continuous growth (Aiwerioghene, Lewis & Rea, 2024). The World Health Organization indicates that assessing the digital maturity of a health system is essential to promote the development and use of digital technologies, based on which national investments can be made (WHO, 2021).

A maturity model describes a state of achieving maturity, i.e., being perfect, complete, ready, etc. (Mettler, 2011). Maturity models define different proficiency levels or effectiveness levels in a particular domain. Each level represents a more advanced and optimised performance state than the previous one. Organisations or individuals can use the model to benchmark their current standing and chart a course for improvement by understanding each level's key characteristics, practices, and capabilities. Organisations use maturity models to manage themselves, and hospitals are no exception (Cimini, Lagorio & Cavalieri, 2024).

Several maturity models have recently been developed for hospitals, and the most widely used maturity model internationally is the Electronic Medical Record Adoption Model (EMRAM) of the Healthcare Information and Management Systems Society (HIMMS) (Neunaber & Meister, 2023). HIMMS (2022) describes it as a strategic roadmap for digital transformation journey toward optimizing organizational performance outcomes and with the help of eight stages, it maps the path to a paperless hospital using EMRs.

The EMRAM model is an eight-stage model that ranges from stage 0 (least mature) to stage 7 (most mature). The EMRAM model evaluates hospitals on various criteria, including (Aiwerioghene et al., 2024):

- the extent to which EMRs support patient care and the degree of integrating different EMR systems.
- The use of tools to support clinical treatment decisions.
- EMR data security and privacy.
- Ability to share EMR data with other healthcare providers.

The EMRAM model is used to benchmark hospital progress in EMR implementation and identify areas for improvement (Neunaber & Meister, 2023). It is also used by payers, regulators, and other stakeholders to assess the overall maturity of the healthcare ICT industry (Aiwerioghene et al., 2024). The eight stages of the EMRAM model (HIMSS, 2021):

- Stage 0: No EMR. At this stage, the healthcare organization still needs to install all the essential ancillary systems such as laboratory, pharmacy, cardiology, radiology, and other departments.
- Stage 1: Basic EMR. Stage 2: Computerized Provider Order Entry (CPOE).
- Stage 3: Clinical Decision Support (CDS).
- Stage 4: Integration (The Computerized Practitioner Order Entry and Electronic prescribing are within an electronic medicines administration record. Clinical and Information governance are functional and well-defined. Monitoring of Clinical outcomes and patient satisfaction targets are met).
- Stage 5: Advanced Clinical Applications.
- Stage 6: Population Health Management.
- Stage 7: Interoperability (integration of data from multiple external sources. Service users receive notifications and reminders to support self-administered care and use automated tools for measuring patient outcomes. Digital infrastructure tools enable dynamic patient involvement in personal health management and care).

The EMRAM model is valuable for hospitals looking to improve their EMR performance. It provides a roadmap for progress and helps hospitals identify improvement areas (Aiwerioghene et al., 2024).

11.12 South Africa's Implementation Strategies

Based on the Digital Health Strategy 2019-2024 (NDoH, 2019), the NDoH Health System Maturity approach emphasises optimal project engagement, patient flow processes in facilities, and using digital health systems such as HPRNs or EMRs.

The NDoH applies a specific maturity model to phase in a solution and measure the success of the implementation. This model was initially used to implement the Health Patient Record System (HPRS) system and first appeared in the South African Health Review of 2015 (Wolmarans et al., 2015). The Digital Health Chief Directorate adopted it as a framework for implementing digital health solutions. The figure below highlights the levels of the maturity model.

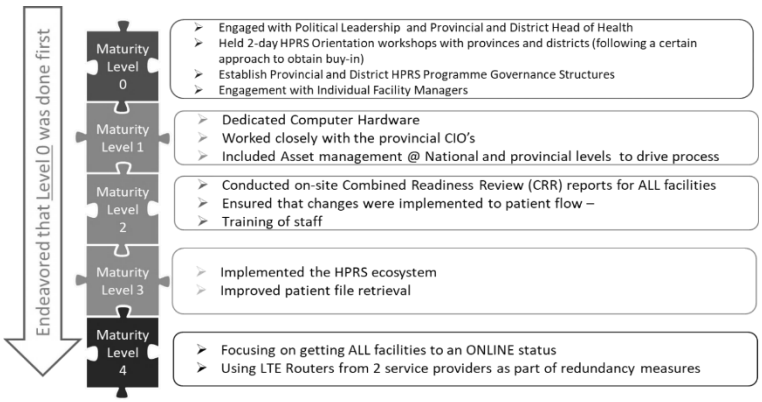

Figure 11-2: Levels used for deploying health solutions (Adapted from Wolmarans et al., 2015)

The model was applied during the HPRS deployment and implementation in health facilities in South Africa (Chapter 9 has a more comprehensive discussion). It will also be applied to the implementation of EMRs in South Africa. It consists of five levels, starting with Maturity level 0 and ending with level 4. Each level has specific steps that need to be fulfilled before it can be considered complete. Even though the programme uses an agile approach for developing the EMR, the level is non-negotiable and should be completed before moving to level 1. This is because communication is essential for the success of the implementation.

The NDoH has also developed the Implementation Toolkit (NDoH, 2024a) as a framework to assist EMR implementation teams, senior managers, and ICT personnel in understanding the necessary activities for the successful implementation of the Electronic Medical Record (EMR) system in public primary health care service facilities in South Africa.

This implementation toolkit is a guide and supports the critical elements of the EMR system implementation process. It will ensure that the implementation process is effective and assist in standardising the processes and ensuring quality delivery (NDoH, 2024a).

The toolkit has attached tools (documents), which will be used to collect evidence and support implementation process improvement collectively while enhancing the quality of the system user experience. It facilitates planning, resource allocation, and time management activities. This document outlines each step and includes practical planning tools. While not exhaustive, this guide can be adapted to meet the unique circumstances of each province or facility (NDoH, 2024a).

The following figure illustrates the high-level EMR implementation process.

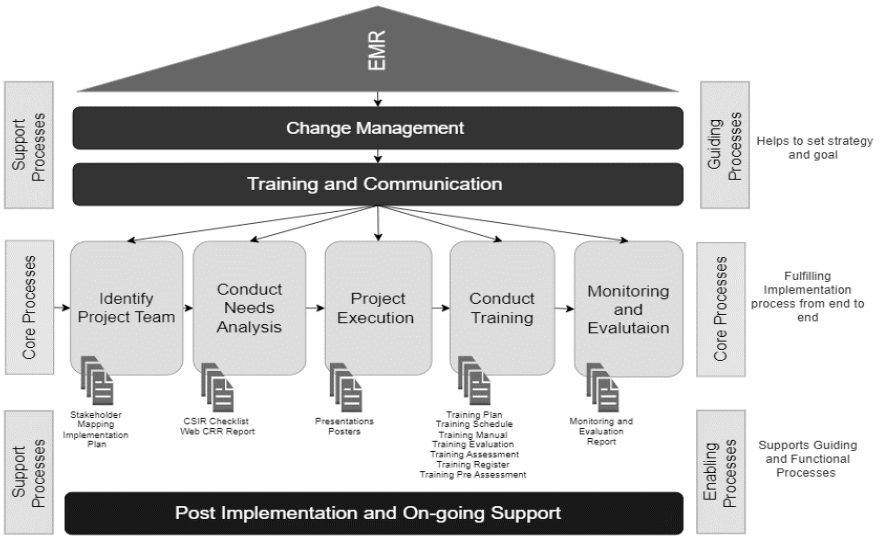

Figure 11-3: The implementation process depicted in the toolkit for implementation of the EMR (NDoH, 2024a)

In implementing and deploying an EMR system, the NDoH will establish a Community of Practice (CoP). The CoP will serve as a professional organizational structure designed to unite key stakeholders, including clinicians, IT specialists, and implementation teams (NDoH, 2024b). By leveraging collective expertise, this CoP will address and resolve challenges within the EMR landscape using shared knowledge, standardised methods, and specialised tools.

In a Community of Practice, a group of professionals can share concerns or their passion for something they do and learn how to do it better through regular interaction (Smith, 2022). Learning should be considered emergent, involving participation in community practices and developing an identity that fosters a sense of belonging and commitment (Smith, 2022). Communities of practice are characterized by knowledge sharing and social construction rather than knowledge transfer as a process of learning (Wulandhari et al., 2021).

This CoP will provide the collaborative environment necessary for stakeholders to work together effectively towards common goals in EMR implementation. The primary purpose of this Community of Practice (COP) is to create a collaborative, supportive, and knowledge-driven environment for EMR champions (NDoH, 2024b). Through this CoP, we aim to ensure the successful implementation, continuous improvement, and sustainability of the EMR system. By facilitating the exchange of best practices and fostering an ongoing commitment to excellence, the CoP will be instrumental in driving both individual and collective success in EMR adoption (NDoH, 2024b).. The objectives of this CoP are to (NDoH, 2024b):

- Facilitate Knowledge Sharing:

- Promote the active exchange of experiences, challenges, and solutions among EMR champions and stakeholders.
- Establish a dynamic platform for discussing best practices, innovative approaches, and lessons learned in EMR deployment.

- Enhance Skills and Competencies:
  - Provide targeted training and professional development opportunities for all CoP members.
  - Ensure that every member has the skills and knowledge necessary for effective EMR implementation, utilisation, and troubleshooting.
- Support Change Management:
  - Cultivate a culture of collaboration, resilience, and continuous improvement within the CoP.
  - Encourage the adoption and optimization of the EMR system through peer support, mentorship, and shared success stories.
  - Improve EMR Implementation:
  - Address implementation challenges proactively and collaboratively, leveraging the collective expertise of CoP members.
  - Develop and refine strategies that enhance user adoption, system functionality, and overall satisfaction with the EMR system.

The CoP is necessary to support stakeholder engagement, knowledge sharing, project management, and technical advisory functions, all within a structured and collaborative framework when implementing the EMR system in South Africa.

11.13 Future EHR

An additional layer should be placed on the EHR system, interconnecting with the other layers via open APIs like Health Catalyst's Data Operating System (DOS). That way, the data operating ecosystem creates real-time insight to meet the aforementioned healthcare transformation challenges of quality care, patient safety and care process efficiency and provides them back to the healthcare ecosystem with its core component EHR system (Blobel, 2018). In detail, the following services have to be provided (Blobel, 2018):

- Real-time analysis of data from multiple data sources to monitor patients.
- Patient dashboards to monitor a patient's overall health and key improvement measures.
- Early detection of at-risk patients.
- Discovery of population health trends.

- Custom rules based on specific data triggers, which can be used to create follow-ups if certain patient health indicators are met.
- Performance insights on staff productivity.
- Data mining capabilities to discover insights on different patient conditions.
- Data analysis to determine the most effective treatment plans for patients.

An early and far simpler approach to such a layered EHR system architecture has been defined and implemented with the Canada Infoway EHR Solution Infostructure (Canada Health Infoway, 2011).

Telemedicine has become a critical component of healthcare delivery, particularly during the COVID-19 pandemic. Integrating EHR systems with telemedicine platforms allows providers to seamlessly access patient data during remote consultations, improving continuity of care and reducing the need for in-person visits (Keesara, Jonas, & Schulman, 2020).

With the rapid integration of artificial intelligence (AI) in healthcare, EHR systems are evolving beyond merely recording patient data to providing advanced decision support, predictive analytics, and personalised care. AI-enabled EHRs hold significant potential to improve diagnostic accuracy and treatment outcomes, particularly in low-resource settings. As digital health continues to advance, adopting emerging technologies like AI and machine learning will be crucial to maximizing the potential of EHR systems and enhancing patient care, especially in low- and middle-income countries (Topol, 2019).

Based on the current developments, adopting new and emerging technologies such as artificial intelligence and machine learning, enabling the flexibility mentioned above and adaptability and accommodating any thinkable use case could be pushed by Google's open source Cloud Healthcare API, introducing a second tier above the EHR system (Lee et al., 2023). Google's API is based on HL7's FHIR API. Adopting the HL7 FHIR standard for interoperability enables real-time data exchange across diverse healthcare systems. FHIR's API-driven architecture facilitates the integration of EHRs with other healthcare applications, improving data accessibility and patient care outcomes (Tan & Xu, 2023).

Cloud-based EHR solutions are becoming the preferred option for healthcare providers due to their affordability, flexibility, and ease of integration with other health systems. These systems allow healthcare providers to access patient data from anywhere, facilitating better coordination of care and improved outcomes, particularly in settings with limited infrastructure (Epizitone, Moyane & Agbehadji, 2023). As an alternative to Google's Cloud Healthcare initiative, Amazon Web Services (AWS) or Microsoft's Azure must be mentioned (Shuaib et al., 2022).

It is suggested by Kosteniuk et al. (2024) that future studies may examine the role of team configuration, size, co-location, and factors such as management, rurality, and other shared

resources. Characteristics of team members might also be considered, as a previous review found EMR adoption by primary care physicians positively associated with female sex and younger age Lee et al., 2023). Lastly, future research should assess the state of EMR/EHR advances in interprofessional contexts and perceptions of utility, such as documentation created by voice-recognition technology and digital assistants (Kosteniuk et al., 2024).

11.14 Regulatory Acts and Policies Governing Implementing an EHR And EMR System in South Africa

11.14.1 Access to Information

The Protection of Personal Information (POPI) Act of 2012 (POPI) (RSA, 2013) and the Promotion of Access to Information Act (PAIA) of 2000 (RSA, 2000) apply to all information repositories, both government and non-governmental. This Act deals with the constitutional right of access to any information held by the SA government. It guarantees access to any information held by another person required to exercise or protect any rights.

The combination of these Acts results in a focus on:

- the protection of personal information processed by public and private bodies.
- conditions to establish minimum requirements for the processing of personal information.
- the establishment of an Information Regulator to exercise certain powers and to perform certain duties and functions.
- issuing of codes of conduct.
- providing for the rights of persons regarding unsolicited electronic communications and automated decision-making.
- regulation of the flow of personal information across the borders of the Republic.

11.14.2 Health Legislation

The National Health Act (RSA, 2003) of South Africa, defines health facilities as facilities that refer to

> *"the whole or part of a public or private institution, facility, building or place, whether for profit or not, that is operated or designed to provide inpatient or outpatient treatment, diagnostic or therapeutic interventions, nursing, rehabilitative, palliative, convalescent, preventative or other health services."*

The development of the EHR should consider the policies and regulations referred to in the Digital Health Strategy (NDoH, 2019) as listed below:

Table 11-5: Legislation impacting the EHR implementation (NDoH, 2019)

Act of Parliament	Purpose
Electronic Communications Security (Pty) Ltd Act, 2002 (Act 68 of 2002)	Privacy and confidentiality of communications.
Electronic Communications and Transactions Act, 2002 (Act 25 of 2002)	Privacy and confidentiality of communications.
Electronic Communications Act, 2005 (Act 36 of 2005)	Basis for universal connectivity.
Protection of Personal Information Act, 2013 (Act 4 of 2013)	Privacy and confidentiality of health records and how they are handled.
The National Archives of South Africa Act, 1996 (Act 43 of 1996)	Defines a set of security protocols and retention requirements for any health record, including electronic records.

The White Paper for NHI Policy (2017) calls for an integrated and enhanced national health information repository and data (NHIRD) system for effectively managing the NHI. This NHIRD will extract a subset of data from the National EHR. The NHIRD will provide data and analytics needed by the National Health Insurance Fund (NHIF) and will be crucial for implementing the NHI and the portability of services for the population (NDoH, 2019).

As mentioned in the introduction, the HNSF was released in 2021 and gazetted in 2022 to provide guidelines for ensuring interoperability in the health sector and recommends the establishment of various registries to manage patients in the health system (NDoH, 2021).

The National Health Insurance Act 20 of 2023 (RSA, 2023) and the National Health Insurance (NHI) fund will be able to make better purchasing decisions through more formal contracting relationships (rather than through historical allocation of budgets by provinces), and so improve the quality of health services available to the majority (Zharima et al., 2023). As EHRs are crucial to monitoring care outcomes, the NHI will be significant in assessing the value obtained by the fund's purchasing decisions.

11.15 Conclusion

Electronic Health Records (EHR) are digital versions of a patient's medical and treatment history, providing a holistic view of their health. They include demographics, test results, medical history, HPI, and medications. EHRs are shared by healthcare providers and can improve patient care and health outcomes. They are not designed to be shared outside the individual practice, but they provide clinicians with access to a wider range of patient data, facilitating better decision-making and care planning. These systems have both challenges and advantages towards supporting Universal Health Coverage and the SDGs.

This literature review provided the background information necessary for South Africa to ensure that the EHR and EMR systems will adhere to not only legislation but also pre-implementation,

implementation and post-implementation suggestions to allow for the effective adoption of these systems by health facilities. Learning from European and other developing countries on their decisions and EHR implementations also heels food for thought for South Africa.

It is crucial to also pay attention to the provision of public communication, stakeholder engagement, infrastructure investment and legal reforms to protect patients' privacy via strict data protection and control for the ultimate benefit of society.

South Africa plans to introduce National Health Insurance to facilitate universal health care. Electronic health records are an integral part of this vision, as they register and monitor patients who use the health system. However, developing a digital health ecosystem for an electronic health record requires long-term commitment, adequate funding, critical skills and expertise and leadership that prioritises and addresses digital health needs.

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Section C: Experiences

Prof. A Botha

In the world of digital health, every experience is a valuable lesson. This category is a treasure trove of real-world narratives and insights. These chapters offer a candid look into the practical experiences, challenges, and triumphs of individuals and organisations navigating the digital health terrain in South Africa. From lessons learned during the implementation of health systems to the impact of digital innovation on patient outcomes, these experiences serve as beacons of wisdom and guidance for those embarking on their own digital health journeys in the diverse and dynamic landscape of South Africa.

Chapter 12: Development and Implementation of the Master Health Facility List (MHFL): Insights from the Free State's 2021 COVID-19 Vaccine Rollout

Tshilo, T.R.,[1] Heunis, J.C.,[2] Chikobvu, P.,[1,3] Ntombela, B.[1]and Litheko, M.[1]

[1]Free State Department of Health; [2]Centre for Health Systems Research & Development, University of the Free State; [3]Department of Community Health, University of the Free State

Purpose: *Reliable communication of health facility-specific information is crucial in supporting health system functions, including routine reporting and emergency responses. The concept of Master Health Facility Lists (MHFLs) garnered significant importance during the COVID-19 vaccination rollout, necessitating a standardised approach to identify health facilities and link facility-level data. Before the COVID-19 pandemic, the National Department of Health (NDoH) maintained a list of public-sector health facilities but lacked comprehensive information on private facilities. This chapter outlines the implementation of the MHFL in the Free State and its evolution alongside the expansion of COVID-19 vaccination efforts.*

Study design: *The implementation and evolution of the MHFL in the Free State followed a participatory action research design. New organisational units were centrally established by facility representatives and curated by administrators at the provincial office. Requests submitted through the system were approved by NDoH representatives, triggering auto-generated notifications for facility representatives to disseminate to district teams. This streamlined process was also applied to the rapid setup of temporary vaccination sites in communities. The rapid expansion of the MHFL facilitated the swift scaling of vaccination efforts.*

Findings: *At the beginning of the vaccination programme, the Free State MHFL incorporated 264 facilities, which evolved to 2,397 by June 2023. The number of patients vaccinated increased from 161,186 in February 2021 to 2,324,763 in June 2023. Non-health facilities like old-age homes were part of the MHFL, and the province recorded vaccination coverage rates of 39.59% and 47.7% among the insured and uninsured populations, respectively.*

Originality/value: *The availability of the MHFL facilitated a streamlined vaccination process and enhanced the quality of data management. Incorporating non-health sites extended vaccination coverage by bringing services directly into the community.*

Keywords: *Master Health Facility List, COVID-19 experiences, Curated*

12.1 Introduction

In an ever-evolving world and environment, effective strategies are essential for preventing, mitigating, and managing all types of disasters, including those caused by communicable diseases. The global COVID-19 pandemic exemplified this need, profoundly impacting healthcare systems and economies worldwide (Nicola et al., 2020). A critical challenge identified during this crisis was the inadequate availability of reliable and actionable information, which significantly hampered disaster response and management efforts (Berchtold et al., 2020). To address these issues, South Africa introduced Master Health Facility Lists (MHFLs) in January 2021 as part of its COVID-19 vaccine rollout strategy. Subsequently, responsibility for managing and updating these lists was delegated to provincial authorities, such as the Free State Department of Health (FSDoH).

A MHFL is a comprehensive inventory encompassing all health facilities within a nation, spanning both the public and the private sectors (Council for Scientific and Industrial Research, 2021). It incorporates administrative data along with a unique identifier for each facility. The MHFL is pivotal in determining the scope of facilities in routine health data collection and is essential for evaluating population health services and infrastructure. Maintaining an accurate and current MHFL is crucial for effective planning, coordination, and delivery of healthcare services. Guidance on establishing MHFLs has been available since 2012 through the World Health Organisation (WHO, 2012).

The imperative for South Africa to establish an MHFL was underscored by the COVID-19 pandemic and subsequent vaccine rollout. During this critical period, the National Department of Health (NDoH) urgently required comprehensive information on all healthcare facilities across both the public and the private sectors, including newly established facilities. This data was essential for effectively tracking, managing, and distributing COVID-19 vaccines. Initially, the NDoH managed lists solely for public healthcare facilities, highlighting the need for a unified inventory encompassing all health facilities nationwide. While the private healthcare sector serves a smaller segment of the South African population compared to the public sector, it remains a significant component of the national healthcare landscape. Developing and implementing the MHFL was thus essential to ensure the NDoH had access to accurate and actionable information on all facilities involved in COVID-19 response efforts, regardless of sector.

Lists of healthcare facilities, such as the MHFL, play a critical role in organising and providing essential information on health services, resource distribution, and identifying coverage gaps (Mbondji et al., 2014). During public health emergencies such as disease outbreaks or mass vaccination campaigns, the MHFL becomes indispensable for reporting health infrastructure capabilities and service provision readiness (Rose-Wood et al., 2014). Governed by national policies, standard operating procedures, and oversight mechanisms, the MHFL ensures the accuracy, integrity, and accessibility of facility data. These policies define the scope and

responsibilities related to MHFL management, including data collection, validation, maintenance, and dissemination practices. They also enforce compliance with regulatory standards and guidelines. Protocols are established for data capture, maintenance, and sharing within the MHFL, emphasising consistency and interoperability across different systems and stakeholders. Clear definitions of data elements, formats, and validation rules ensure data quality and reliability. Ownership rights and access controls are specified to protect privacy and confidentiality, aligning with data protection regulations.

Quality assurance measures include validation checks, verification processes, and periodic audits to detect and rectify errors or outdated information. Security protocols are implemented to safeguard MHFL data, employing encryption methods, access controls, and privacy policies to prevent unauthorised access or misuse. The National Health Information Systems of South Africa (NHISSA) committee oversees MHFL implementation and management across provinces, ensuring adherence to standards and guidelines. Training programmes are provided to provincial teams, both public and private, to enhance understanding of MHFL roles, data management practices, and utilisation of related tools and technologies. Monitoring and evaluation mechanisms are integral in assessing the effectiveness and impact of the MHFL in supporting informed health decision-making and response strategies during public health crises and routine healthcare operations.

This chapter aims to detail the implementation of the MHFL in the Free State province and its evolution in tandem with the expansion of COVID-19 vaccination efforts.

12.2 COVID-19 Outbreak and Vaccine Rollout

The WHO elevated the COVID-19 outbreak to a public health emergency of international concern on January 30, 2020 (COVID-19 Vaccine Delivery Partnership, 2023). Subsequently, as the virus spread rapidly around the globe, it was declared a global pandemic, severely impacting global societal and economic operations and overwhelming healthcare systems (Nicola et al., 2020). COVID-19 is primarily transmitted through respiratory droplets, prompting swift implementation of social and public health measures to mitigate its spread (Güner, Hasanoğlu, & Aktaş, 2020). However, these measures provided only temporary relief, emphasising the urgent need for safe and effective vaccinations to contain the outbreak.

In response to the crisis, the rapid development of COVID-19 vaccines ensued, accompanied by WHO guidelines to assist countries in prioritising distribution to the most vulnerable populations amidst initially limited vaccine supplies (WHO Regional Office for the Western Pacific, 2022). Globally, extensive vaccine administration across diverse age groups became imperative to achieve high population coverage and desirable immunity levels. Key requirements for effective vaccine management included expanding cold chain capacity, establishing vaccination sites, and stimulating public demand for the vaccine (COVID-19 Vaccine Delivery Partnership, 2023).

12.3 Need for a Master Health Facility List

The rapid deployment of COVID-19 vaccines necessitated the swift development and adaptation of health information system tools to track vaccine implementation and guide operational strategies (COVID-19 Vaccine Delivery Partnership, 2023). Unlike routine immunisation schedules in many countries, COVID-19 vaccines required modifications to vaccination monitoring systems to enable real-time tracking. Existing systems were enhanced, and new systems were developed to facilitate pre-registration, appointment scheduling, target group control, and vaccination headcount monitoring.

According to Statistics South Africa, the Free State province is home to more than 2.9 million residents (Stats SA, 2022). Within the province, there are 219 public clinics and 32 public hospitals (FSDoH, 2022), comprising a total of 251 health institutions that range from basic primary health care (PHC) facilities (e.g., clinics and community healthcare centres) to specialised and university hospitals (FSDoH, 2022). During the initial phase of the COVID-19 outbreak in 2020, the epicentre within the Free State was primarily concentrated in densely populated areas, particularly the Mangaung Metropolitan Municipality. In response to the subsequent vaccine rollout in 2021, temporary clinics, often called *pop-up* sites, were swiftly established to enhance vaccine accessibility and coverage.

Before the COVID-19 pandemic, the Free State province had existing health facility information systems, such as the District Health Information System (DHIS), which served as a standard health surveillance tool. Additionally, systems such as the Health Patient Registration System (HPRS) for patient registration and TIER.net for monitoring HIV and tuberculosis (TB) patients were in place. While functional, these systems were not originally designed to manage the complexities of a pandemic such as COVID-19, including vaccine rollout logistics, management of related cases, *pop-up* site coordination, and other COVID-19-specific tasks across the public and private sectors.

Various stakeholders collaborated with the NDoH to combat COVID-19 and successfully implement the vaccination programme, necessitating the sharing of pertinent information related to COVID-19 and the vaccine across all involved parties. Unlike other pre-existing health information systems, the MHFL includes essential administrative data that categorises each facility and outlines its operational status. Typically, the MHFL captures information such as the facility name, location, services offered, bed capacity, and contact details. In the Free State province, the MHFL emerged as a standardised tool for identifying healthcare institutions and integrating facility-level data during the COVID-19 vaccine rollout. This pivotal role stems from the MHFL's capability to reliably communicate facility-specific information, effectively supporting health system operations, routine reporting, and emergency responses.

At the onset of the vaccination programme, priority was given to the elderly population (65 years and older) due to their increased susceptibility to severe outcomes from COVID-19, often exacerbated by underlying health conditions. The Free State province achieved 90% vaccination

coverage in this age group in less than three months. Subsequently, attention shifted to the 50-59 age group, where the 90% target was reached in under two months. The 40-49 age group, known for its higher mobility and easier access to healthcare facilities, achieved vaccination coverage even faster than the elderly population. Following the successful vaccination of these age groups, registration opened for all individuals aged 18 years and older. Progress in vaccinating this cohort at first lagged, possibly due to vaccine hesitancy arising from concerns and controversies surrounding the Pfizer vaccine initially administered. However, with the availability of the Johnson & Johnson vaccine, interest in vaccination among younger adults increased. Eventually, the province achieved at least 90% vaccination coverage in this broader adult age group.

12.4 Development and Use of the Master Health Facility List

The initiation of COVID-19 vaccination studies among healthcare workers in South Africa highlighted the immediate necessity for a MHFL to facilitate the broader vaccination effort for the general population (Bekker et al., 2022). According to the WHO (2019), the MHFL is a comprehensive inventory of all health facilities within a country, serving as the foundational dataset from which all other facility lists are derived. This list plays a crucial role in disease surveillance, supports health management information systems, aids in achieving intervention coverage goals, and facilitates supply chain planning and management. The MHFL is typically maintained within a facility registry service or health information system accessible to relevant authorities needing comprehensive health facility information.

Constructing a comprehensive MHFL to underpin evidence-based decision-making and healthcare planning necessitates the collaboration of a multidisciplinary team comprising individuals with diverse expertise and specific responsibilities. Among the pivotal roles and personnel involved in the development of the MHFL process in the Free State were:

- The MHFL project manager is based at the NDoH and supported by the Free State MHFL team. The NDoH was responsible for overseeing the entire MHFL development process, including planning, coordination, and monitoring of activities. The NDoH further provided guidance on legal and regulatory requirements related to health facility registration, data privacy, and confidentiality. The project manager ensured the MHFL complied with relevant laws, regulations, and ethical standards.
- The NDoH team developed and provided training programmes for provincial teams (both public and private) involved in MHFL development and management. They ensured that users understood their roles and responsibilities, the data collection methods, and the required data management practices.
- The provincial MHFL team collected, cleaned, and analysed facility data from multiple sources. They ensured data quality, identified inconsistencies, and prepared the data for inclusion in the MHFL. The team ensured facility data was organised and classified according to standard terminology and classification systems that NDoH provided. They

also identified gaps in coverage and supported spatial decision-making in healthcare planning.

- Facility representatives provided knowledge and expertise related to healthcare delivery and facility management. They ensured that the MHFL included relevant information about diverse types of healthcare facilities, services offered, and operational characteristics.
- District pharmacists assisted with fieldwork and data collection activities, particularly with pop-up sites meant to improve vaccine access to the general population. In addition, they assisted with verifying facility information, gathered additional data, and engaged with local communities.

The process of developing the MHFL was a joint effort of 1) the NDoH project manager who oversaw the entire process, 2) district pharmacists who identified the facilities to be included in the list, 3) facility representatives who managed the facility and made sure that the vaccine stock and consumables were available, 4) provincial curators who assigned all the sites to their respective subdistricts, and 5) the provincial MHFL team who approved the sites and worked with NDoH to certify the sites.

The MHFL team in the Free State province embraced the six building blocks for PAR proposed by Cornish et al. (2023): 1) building relationships; 2) establishing working practices; 3) fostering a shared understanding of the issue; 4) observing, gathering, and generating materials; 5) collaborative analysis; and 6) planning and acting. Additionally, they adhered to the cyclical nature of PAR, wherein each phase informed the next, as Cornish et al. (2023) outlined. This iterative approach involved collaborative analysis and reflection on actions and their impacts, enabling continuous learning and refinement of strategies. Throughout these cycles, building relationships was an ongoing process involving the engagement of other teams, such as those responsible for site certification, to enhance the efficiency of the certification turnaround time.

12.4.1 Fixed Facilities – Public Sector

The NDoH initially utilised a list of fixed facilities providing routine services as the first selection of vaccination sites across districts and subdistricts. Each vaccination site required certification facilitated jointly by the NDoH and the provincial MHFL team. District pharmacists within each district were responsible for identifying facilities to be included in the MHFL and completing the Vaccine Site Checklist (Annexure A), which detailed essential site information. This information was then shared with the provincial MHFL team for review and inclusion.

Facilities were considered suitable for inclusion on the MHFL if they met all criteria outlined in the checklist, including site name, number of vaccinators, address, and operational days. During the initial vaccination phase, under the Sisonke Study (Bekker et al., 2022), all sites were associated with a single primary distribution site where vaccines were stored. For instance, sites in Mangaung were linked to Universitas Academic Hospital, Lejweleputswa to Bongani Regional

Hospital, and Xhariep to Albert Nzula Hospital. This setup posed challenges as it hindered the ability of districts to report vaccination data per subdistrict, thus impeding effective monitoring and support for underperforming areas. To overcome this issue, the NDoH collaborated with facility representatives and the provincial curator to assign each site to its respective subdistrict. This reassignment enabled data to be aggregated and monitored at the subdistrict level, facilitating targeted support and intervention where needed.

The MHFL encompassed both public and private facilities, requiring distinct handling depending on the sector. Private facilities, such as those under Mediclinic, necessitated the involvement of private facility representatives and curators, distinct from their counterparts in the public sector, which the public facility representative and provincial curator oversaw. Similarly, facilities under the South African National Defence Force (SANDF) operated under their own facility representatives and curators.

While the public provincial MHFL team provided training and support within the private sector, management of other government department facilities, such as those under the Department of Education, fell under the purview of the NDoH. This division of responsibilities ensured comprehensive coverage within the MHFL while maintaining specialised oversight tailored to each sector's unique operational requirements.

12.4.2 Pop-up Sites

Once the data was accurately reallocated to the correct subdistricts, identifying regions with vaccine accessibility challenges and areas falling short of vaccination targets became more straightforward. District pharmacists were tasked with devising strategies to reach populations encountering difficulties accessing vaccination sites. This led to the implementation of pop-up vaccination sites strategically placed in locations with concentrated target populations or areas showing increased COVID-19 cases. Pop-up sites were temporary installations designed to address local needs swiftly. District pharmacists submitted vaccine site checklists for these pop-up sites, detailing operational specifics. The MHFL team then linked these to their respective distribution sites, which were locations where vaccines were supplied to *pop-up* sites. This coordinated approach ensured an effective health response to COVID-19 vaccination distribution in the Free State province. The comprehensive list developed, standardised, and validated as the MHFL for the Free State (Blasioli, Mansouri, Tamvada, & Hassini, 2023) played a pivotal role in guiding and coordinating this vaccination effort.

12.5 Participatory Action Research

Following the approval of COVID-19 vaccines by the South African Health Products Regulatory Authority (SAHPRA) in January 2021, the NDoH mandated each province to update its MHFL. In response, the Free State information management team was tasked with creating a unified, comprehensive list encompassing all public and private outreach health sites, as well as temporary

pop-up facilities, as part of the provincial MHFL development process. The development and implementation of the MHFL coincided with the FSDoH's COVID-19 vaccination rollout. Participatory Action Research (PAR) was chosen as the most appropriate design due to its integration of both action and research processes during MHFL development and utilisation. PAR involves collective, self-reflective inquiry by researchers and participants to understand and enhance their practices and contexts (Burns, 2009). According to Baum (2006, p. 854):

> *PAR seeks to understand and improve the world by changing it. At its heart is collective, self-reflective inquiry that researchers and participants undertake so they can understand and improve upon the practices in which they participate and the situations in which they find themselves. The reflective process is directly linked to action, influenced by an understanding of history, culture, and local context and embedded in social relationships.*

Multiple stakeholders were involved in developing and implementing the MHFL in the Free State province, including partners from the NDoH, provincial information management staff, Department of Education staff, Department of Social Development staff, and both public and private health facility staff. The NDoH assumed leadership in overseeing the MHFL development and implementation process and published the initial updated list in February 2021.

The primary objective of the MHFL in the Free State was to establish and maintain coherence in communication concerning the vaccine rollout across designated facilities. Selected facilities earmarked for use as vaccination sites were systematically recorded in the system by the Health Facility Technical Working Group (2024). Each facility was assigned a unique identifier code and included details such as facility name, address, type, and managing entity.

District pharmacists were tasked with ensuring the inclusion of every new facility into the MHFL, while the FSDoH Information Management and ICT teams maintained ongoing oversight. Their responsibilities included continuously monitoring the list, rectifying errors, and eliminating duplicates to uphold data accuracy and reliability.

Implementing and developing the MHFL in the Free State province adhered to a PAR methodology. PAR aims to investigate and address issues simultaneously in real-time. In order to streamline the process, all new organisational units were centrally created by facility representatives at the provincial level and overseen by the provincial curator. This decision followed observations by the MHFL team of delays in site creation and approval when handled at lower levels or individual facilities. In response, the FSDoH centralised the application process for new sites to the provincial MHFL team, ensuring all communication flowed between the NDoH and FSDoH. Within the MHFL system, NDoH representatives were empowered to approve each request, with automatic notifications sent to facility representatives to inform district teams of newly approved sites. Using a standardised process, this centralised approach facilitated the rapid establishment of temporary immunisation facilities in community settings, such as halls and old

age homes. As will be evidenced in the next section, the rapid expansion of MHFLs significantly enhanced the distribution of vaccines and contributed to improved vaccine coverage across the province.

12.6 Results

From March 2021 to June 2023, a total of 203 primary distribution sites, authorised with Section 22 permits for overnight vaccine storage, were registered on the MHFL (Figure 12-1). Each of these primary distribution sites also doubled as a vaccination site. The rise in the number of sites directly correlated with an increase in the number of vaccinations administered during this period.

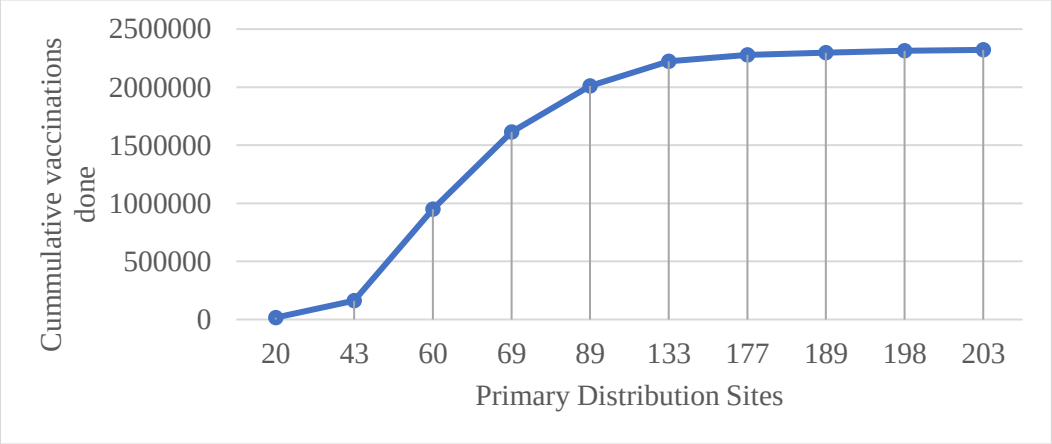


Figure 12-1: Primary Distribution Sites vs. Total Cumulative Vaccinations. Source: NDoH (2024)

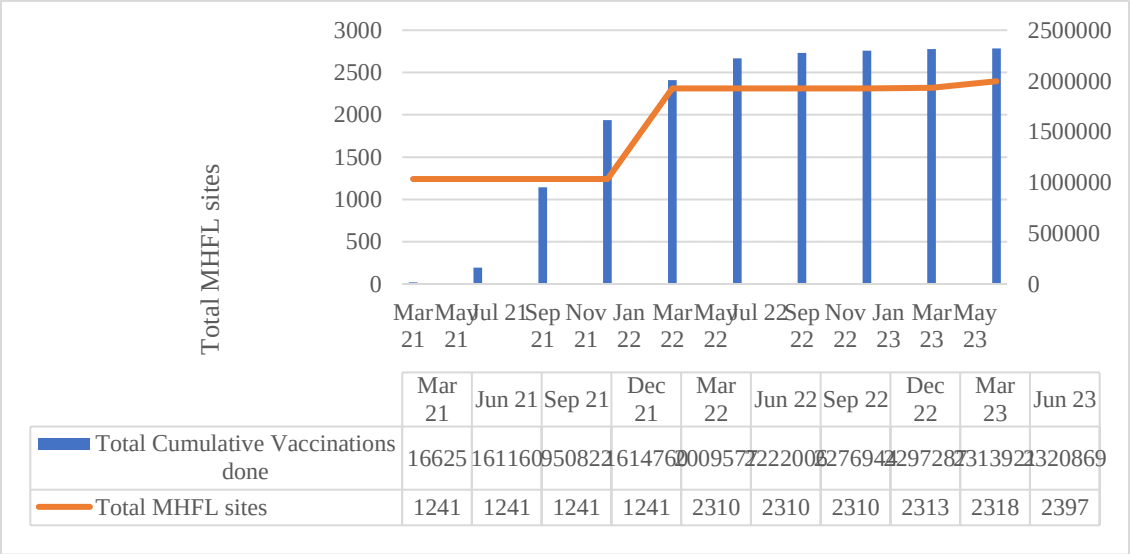
Table 12-1 illustrates the distribution of vaccinations across districts in the Free State province. During the vaccination campaign, a total of 1,351,553 individuals received vaccinations, resulting in vaccination coverage of 46.60%. The highest number of vaccinations occurred in Mangaung Metro, where the vaccination coverage reached 50.21%. Thabo Mofutsanyana district followed closely with a coverage of 48.77%.

Table 12-1: Free State Vaccines Administered per District (Source: NDoH (2024)

District	Population	Total individuals vaccinated	Vaccination coverage (%)	Total vaccines administered
Fezile Dabi	505,055	214,796	42.53	359,706
Lejweleputswa	643,038	274,144	42.63	500,469
Mangaung Metro	869,265	436,442	50.21	768,708
Thabo Mofutsanyana	755,840	368,606	48.77	671,679
Xhariep	127,070	57,565	45.30	86,905
Free State	2,900,268	1,351,553	46.60	2,327,467

In January 2021, when the COVID-19 vaccine rollout commenced, there were 264 facilities listed in the MHFL. By June 2023, this number had surged to 2,397 facilities (Figure 12-2). These sites

encompass fixed healthcare facilities, outreach sites, pop-up sites, and primary distribution sites. The significant increase in registered facilities on the MHFL proved beneficial, correlating with a corresponding rise in vaccination numbers over time. Outreach and pop-up sites were crucial in expanding vaccination reach, enabling the FSDoH to immunise more individuals. The MHFL also included non-health facilities such as old age homes, malls, stadiums, and community halls, underscoring its inclusive approach to vaccination site registration.



	Mar 21	Jun 21	Sep 21	Dec 21	Mar 22	Jun 22	Sep 22	Dec 22	Mar 23	Jun 23
Total Cumulative Vaccinations done	16625	161160	950822	1614762	2009577	2222006	2276944	2297282	2313922	2320869
Total MHFL sites	1241	1241	1241	1241	2310	2310	2310	2313	2318	2397

Figure 12-2: Cumulative Vaccinations Done and Master Health Facility List Sites, March 2021 - June 2023. Source: NDoH (2024)

In total, 2 327 467 vaccine doses were administered in the Free State province (Table 12-2). This includes 1 351 912 first doses, 667 937 second doses, and 290 316 booster doses. The vaccination coverage differed between insured and uninsured populations, with coverage rates of 39.59% and 47.7%, respectively (Table 13-3).

Table 12-2: Free State Cumulative Vaccines Administered by District (NDoH, 2024

District	First dose vaccines administered	Second dose vaccines administered	Sisonke booster dose vaccines administered	Immuno-compromised additional dose vaccines administered	General booster dose vaccines administered	Continuous booster dose vaccines administered	Total vaccines administered
Fezile Dabi	214,821	101,624	1,550	13	40,950	748	359,706
Lejweleputswa	274,168	160,828	1,598	29	62,587	1,259	500,469
Mangaung	436,631	225,934	6,221	115	98,140	1,667	768,708
Thabo Mofutsanyana	368,702	164,558	2,417	15	74,788	1,199	611,679
Xhariep	57,590	14,993	409	1	13,851	61	86,905
Total	1,351,912	667,937	12,195	173	290,316	4,934	2,327,467

Table 12-3: Free State Vaccination Coverage by District (NDoH, 2024)

District	Total population	Total individuals vaccinated	Vaccination coverage (%)	Insured population	Insured (self-reported) individuals vaccinated	Insured (self-reported) coverage (%)	Uninsured population	Uninsured (self-reported) individuals vaccinated	Uninsured (self-reported) coverage (%)
Fezile Dabi	505,055	214,796	42.53	69,034	20,341	29.47	436,026	194,455	44.60
Lejweleputswa	643,038	274,144	42.63	79,763	35,969	45.09	563,276	238,175	42.28
Mangaung	869,265	436,442	50.21	155,028	76,121	49.10	714,238	360,321	50.45
Thabo Mofutsanyana	755,840	368,606	48.77	76,196	20,650	27.10	679,649	347,956	51.20
Xhariep	127,070	57,565	45.30	13,424	2,694	20.07	113,642	54,871	48.28
Total	2,900,268	1,351,553	46.60	393,445	155,775	39.59	2,506,831	1,195,778	47,70

12.7 Discussion

This section addresses the challenges associated with implementing the MHFL, explores its alignment with the National Digital Health Strategy 2019-2024 (NDoH, 2019), and discusses both limitations and proposed enhancements.

12.7.1 Challenges in Implementing the Master Health Facility List

In the Free State, established systems exist to manage health facility information for specific purposes (Cline & Luiz, 2013). The global response to the COVID-19 pandemic underscored the necessity for nations to navigate considerable uncertainty with limited foresight (Janssen & Van der Voort, 2020). Enhancing healthcare accessibility became paramount, with expanding healthcare facilities emerging as a primary strategy. Despite the presence of systems housing health facility data, the lack of standardised naming and exclusive coding processes resulted in identification ambiguities and duplicated information (Kruk et al., 2018). Despite having access to essential information on all existing facilities in the Free State, integrating disparate information sources posed challenges in monitoring facilities offering COVID-19 vaccine services. Consequently, a need arose to establish a MHFL in the Free State.

The ownership of the MHFL in South Africa rests with the NDoH, which assumes responsibility for its administration, verification, and communication channels, ensuring comprehensive oversight. While the development of the MHFL was decentralised to the provinces by the NDoH, it remains centrally updated and managed by the national authority. Implementing the MHFL in the Free State presented coordination challenges, particularly when facility representatives were not promptly identified. This necessitated a requirement for a facility representative to be identified before inclusion on the MHFL.

Despite the MHFL's ongoing updates and rigorous quality control through a PAR cyclical process, these activities added to the workload of the MHFL team. Nevertheless, they were essential for data maintenance, improving data quality, and eliminating duplicate records. Another significant challenge was obtaining facility certificates, which were centralised at the NDoH. The NDoH

collaborated with site certification offices to expedite this process, enhancing certification turnaround times.

Additional challenges included data quality issues, such as incomplete checklists, which compromised data accuracy and completeness. In order to address this, district pharmacists were enlisted to assist facilities in completing the checklist. Harmonising data at the subdistrict level posed further challenges, particularly as some sites from different districts were linked to Universitas Hospital as a primary distribution site, necessitating ongoing data validation efforts. Despite the prolonged process of delinking these sites from Universitas Hospital, an eventual resolution was achieved. Virtual training also posed challenges initially, requiring time for provincial teams to familiarise themselves with MHFL tools. Eventually, the NDoH provided instructional videos as part of training efforts to continually educate provincial teams on MHFL utilisation.

12.7.2 Alignment with National Health Digital Health Strategy 2019-2024

The National Digital Health Strategy 2019-2024 (NDoH, 2019) aims to enhance health outcomes and healthcare system efficiency by leveraging digital technologies. It focuses on improving data quality and accessibility through interoperable health information systems, enhancing health system responsiveness, ensuring equitable access to health services, and strengthening governance and policy frameworks. By promoting innovation and collaboration among public, private, and international partners, the Strategy seeks to transform healthcare delivery and outcomes, extending services to underserved areas and supporting timely decision-making during public health emergencies.

The MHFL project, as implemented in the Free State during the COVID-19 vaccination efforts, signifies a notable advancement in South Africa's health information system infrastructure. This section explores how the MHFL aligns with the National Digital Health Strategy 2019-2024, identifies its limitations, and proposes enhancements to amplify its impact.

The MHFL project aligns with the core objectives of the National Digital Health Strategy 2019-2024 by improving data quality and accessibility, enhancing health system responsiveness, and ensuring equitable access to health services. Firstly, the MHFL provides a comprehensive, standards-based catalogue of health facilities, integrating data from both the public and private sectors. This comprehensive approach supports the Strategy's goal of developing interoperable health information systems, subsequently improving data quality and accessibility (Council for Scientific and Industrial Research, 2021). Secondly, the MHFL facilitates the rapid expansion and coordination of vaccination sites during the COVID-19 pandemic, demonstrating its capacity to support agile public health responses. Including temporary and non-health facilities in the MHFL enabled broader vaccine coverage and improved accessibility, aligning with the Strategy's emphasis on enhancing health system responsiveness. Lastly, by providing detailed geographic and operational data on health facilities, the MHFL supports targeted interventions in underserved

and remote areas. This effort aligns with the Strategy's objective of promoting equitable health service delivery, ensuring all population segments have access to necessary health services (NDoH, 2019).

12.7.3 Limitations

Despite its significant contributions, the MHFL project faced several challenges. One major issue was data quality. Incomplete and inconsistent data submissions, particularly from newly established facilities and temporary sites, compromised the accuracy and reliability of the MHFL. Another challenge was coordination. The decentralisation of MHFL development to provincial levels led to coordination difficulties among provincial teams, highlighting the need for more streamlined processes and better interprovincial communication.

Additionally, while the MHFL improved facility data management, its integration with other health information systems requires further enhancement to ensure seamless interoperability. Effective integration is crucial for creating a cohesive health information infrastructure (NDoH, 2019).

12.7.4 Proposed Enhancements

Four measures are proposed to address these limitations and strengthen the MHFL project. Firstly, enhancing capacity building through ongoing training and support for provincial and facility-level staff can improve data quality and consistency. Utilising digital tools and platforms for training can ensure wider reach and accessibility (Council for Scientific and Industrial Research, 2021). Secondly, establishing robust data governance frameworks, including standardised data collection protocols and regular audits, can enhance the accuracy and reliability of the MHFL. Centralised oversight and coordination by the NDoH can ensure consistency across provinces (NDoH, 2019). Thirdly, strengthening the interoperability between the MHFL and other digital health systems is essential. Implementing interoperability standards and promoting common data exchange protocols can facilitate seamless data sharing and integration (WHO, 2019). Fourthly, engaging a broader range of stakeholders, including private sector partners and community organisations, can enhance the comprehensiveness and utility of the MHFL. Collaborative efforts can address gaps in facility data and support more effective health service delivery.

In conclusion, while the MHFL project demonstrated significant alignment with national digital health objectives, addressing its current limitations through targeted enhancements is crucial for realising its full potential in supporting South Africa's health system transformation. By improving data quality, coordination, system integration, and stakeholder engagement, the MHFL can significantly contribute to the effective delivery of health services and the achievement of the National Digital Health Strategy 2019-2024 goals.

12.8 Value

Despite encountering challenges, the availability of MHFLs significantly streamlined the vaccination process and enhanced data quality. Utilising non-health sites extended vaccination coverage by bringing services directly to communities. Successful collaboration between the public and private sectors further bolstered these efforts. The involvement of district pharmacists notably contributed to the comprehensive expansion of the MHFL, facilitating the incorporation of diverse healthcare facilities such as pop-up sites, subsequently ensuring a more accurate and inclusive representation.

Moreover, integrating data visualisation tools and dashboards enabled users to explore and analyse MHFL data in intuitive and interactive formats. This enhanced usability has empowered decision-makers to make informed and effective choices based on comprehensive insights derived from the MHFL.

In Nigeria, a comprehensive effort to compile the Master Facility List (MFL) nationwide was completed in 2013 (Measure Evaluation, 2019). The 2013 MFL included hospitals and clinics, providing detailed information on their geographic locations, range of medical services offered, and ownership status. Serving as a comprehensive directory of healthcare facilities, the MFL encompassed both government-run and privately-owned health institutions. According to the authors, Nigeria realised substantial benefits from the adoption of the MFL. It facilitated a deeper understanding of the distribution and characteristics of health resources, resulting in enhanced efficiency in healthcare management through centralised data. Furthermore, the MFL allowed for data comparison across various surveys and time frames, fostering collaboration between departments and ministries to optimise data utilisation.

A recent study in Senegal highlighted the absence of a centralised MFL (Gueye et al., 2024). Nonetheless, the broader Senegalese data landscape offers multiple sources that can potentially be integrated into a unified database. Initially, 12,965 facility records from 16 distinct datasets and lists across Senegal were compiled as a foundational step towards establishing a comprehensive MFL. Employing algorithms, manual verification, and revision processes enabled the identification of unique facilities and determining their respective GPS coordinates. Ultimately, this effort yielded an aggregated list of 4,685 facilities, with 2,423 with at least one set of GPS coordinates (Gueye et al., 2024). Developing strategies to leverage current data for future MFL development can address data gaps and refine methodologies for conducting thorough facility surveys, particularly focusing on regions and facility types with limited information availability. Going forward, regular updates to existing facility lists and strengthening government-led data collection systems are crucial for ensuring timely data accessibility to inform health policy and decision-making (Gueye et al., 2024).

12.9 Conclusion

The vaccination campaign, launched in January 2021 in the Free State, commenced with 264 registered facilities. By June 2023, this network had grown significantly to encompass 2,397 facilities, resulting in a corresponding rise in vaccination coverage, with a cumulative total of 2,327,467 doses administered by that date. The MHFL initiative extended across various institutions, such as retirement homes, contributing significantly to the province achieving an immunisation rate of 46.60%.

The efficient delivery of healthcare services and effective planning is contingent upon a national MHFL that is accessible, accurate, and consistently updated. Establishing a functional MHFL was crucial during the 2021 COVID-19 vaccination programme, enabling effective coordination and response efforts. A pre-populated, comprehensive, accurate, and regularly updated MHFL would have substantially facilitated initial response efforts during emergencies, highlighting the critical need for nations to establish and maintain MHFLs. This infrastructure enables efficient and well-coordinated responses to communicable disease outbreaks.

Implementing the MHFL represented a significant advancement in the healthcare data infrastructure of the Free State, providing a standardised repository of facility information. This development facilitated informed decision-making in healthcare planning, resource allocation, and service delivery, notably during the COVID-19 vaccination campaign. Centralising the MHFL streamlined administrative processes, reduced duplication of efforts, and improved facility mapping, monitoring, and reporting efficiency. Additionally, it established a standardised foundation for facility data and enabled the integration of other health data elements. This framework also identified gaps in coverage and disparities in healthcare access.

In conclusion, establishing an MHFL represents a pivotal milestone in strengthening healthcare information systems and enhancing access to quality healthcare services for communities in the Free State province. However, its full potential can only be realised through continuous efforts in data management, governance, and utilisation. These ongoing initiatives are essential to effectively support broader health system goals and objectives.

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Annexure A – Vaccine Site Checklist (version 5.2)

Vaccination Site Enrolment

The South African National COVID-19 Vaccine Implementation Plan describes multiple scenarios where vaccines will be administered. Vaccination sites will be located in both public and private sector settings, and will include fixed, mobile and temporary locations.

All COVID-19 vaccination sites are required to be enrolled with the National Department of Health (NDoH). Enrolment will assist with planning, distribution, communication, monitoring and reporting on progress of the vaccination rollout plan.

Acronyms

AEFI	Adverse Event Following Immunisation
EVDS	Electronic Vaccination Data System
NDoH	National Department of Health

Definitions

Immunisation station means the area in a vaccination site where vaccines are administered to clients.

COVID-19 vaccination services mean administering COVID-19 vaccines to eligible recipients.

Vaccination site means a health establishment or other site which is authorised to provide COVID-19 vaccination services to clients.

Vaccinator means the person who administers a COVID-19 vaccine to a client

Vaccination site details

Facility name: _____

Physical address: _____

Postal address: _____

Province: _____

District: _____

Sub-District: _____

Contact number: _____

Type of facility:

☒ District Hospital
☐ Regional Hospital
☐ Tertiary Hospital
☐ Central Hospital
☐ Specialised Hospital
☐ Community Day Centre
☐Primary Health Care Clinic
☐ Other

☐ Private Hospital
☐ Private Day Hospital
☐ Private Clinic
☐ Private Pharmacy
☐Private Practitioner
☐ Community Health Centre

Please specify other:

_____

Facility ownership:

☒ Government
☐ Non-government organisation
☐ Military
☐ Other

☐ Private for profit
☐ Faith based organisation

Please specify other:

_____

Please specify:
Responsible pharmacist: _____
Contact number: _____
Contact email: _____
SAPC Registration number: _____
Responsible person: _____
Contact number: _____
Contact email: _____
Registration or Practice Number:_____
Registration in terms of:

☐ Pharmacy Act 53 of 1974 (Pharmacy Act);

☐ Medicines and Related Substances Act 101 of 1965 (Medicines Act);

☐ Nursing Act 33 of 2005;

☐ Health Professions Act 56 of 1974

Cold storage capacity
Total number of 2-8ºC fridges available for vaccine storage: _____
Available storage capacity (2-8ºC) in cm^3 or litres: _____
Are WHO approved continuous temperature monitoring devices present in the cold storage area:

☐ Yes ☐ No

If the answer above is *No*, temporary approval to enrol as a Vaccination site will be provided, and the Vaccination site must provide an update on the status within 30 days.
Estimated number of vaccinators: _____
Vaccine Site ICT Requirements:

☐ Internet Access

☐ Dedicated Computer / Laptop for capturing on EVDS

☐ 1D Barcode Scanner

☐ 2D Barcode Scanner

Types of Vaccination services provided

☐ Static service only

☐ Outreach services only

☐ Static and outreach services

Operating Hours for vaccination services
Monday: _____ to _____
Tuesday: _____ to _____
Wednesday: _____ to _____
Thursday: _____ to _____
Friday: _____ to _____
Saturday: _____ to _____
Sunday: _____ to _____
Public Holidays: _____ to _____

COVID-19 VACCINATION SITE REQUIREMENTS

All COVID-19 vaccination sites must be able to adhere to the following requirements:

- Compliance
- Vaccination sites must comply with all applicable legislation including but not limited to:
- Pharmacy Act 53 of 1974 (Pharmacy Act);
- Medicines and Related Substances Act 101 of 1965 (Medicines Act);
- Nursing Act 33 of 2005;
- Health Professions Act 56 of 1974; and
- National Health Act 61 of 2003.
- Vaccination sites must also comply with the rules relating to good pharmacy practice made in terms of section 35A of the Pharmacy Act, 1974.
- Other applicable policies and guidelines provided by the National or Provincial Departments of Health.
- General
- Vaccination sites must comply with the following general requirements.
- Vaccination sites must
- be easily accessible to clients;
- be arranged in such a way that social distancing can be maintained in both waiting areas and at immunisation stations;
- establish and implement a mechanism of setting up appointments to prevent crowding and plan immunisation sessions to minimise vaccine wastage.
- Vaccination sites will determine and make available the days and times that services will be provided at the site. This information must be readily available to the public or the community to the served at a vaccination site (as applicable).
- A list of vaccinators providing services at each site must be provided to the National Department of Health
- On enrolment as a vaccination site, the volume of cold storage available at the site will be provided. The cold chain storage will be determined and submitted (H x W x D) to determine the available volume (cm3))
- COVID-19 vaccines may not be sold, and vaccination sites may not seek reimbursement for any vaccines, syringes, needles, or other ancillary supplies that the government provides without cost to the site.
- Vaccine Management
- In Phase I, Vaccines will be supplied based on the number of estimated recipients expected to visit the vaccination site. In Phases II and III, the Vaccination site will need to monitor uptake and demand and place appropriate orders as per instruction provided.
- Documentation relating to proof of delivery at the vaccination site must be signed by a person duly authorised to do so. The person receiving the stock must indicate receipt thereof and note any discrepancies found. Risk in and to the vaccines will pass to the vaccination site upon signature acknowledging receipt.
- Fine checking procedures must be completed upon receipt of the vaccines and any discrepancies reported to the relevant district manager within two (2) days of receipt, failing which the vaccination site shall be deemed to have received the vaccines in the quantity, condition and description reflected in the signed receipt.
- Vaccines must always be managed in accordance with the applicable rules relating to good pharmacy practice and the provisions of the National Cold Chain and Immunisation Manual 2015. These requirements include, but are not limited to the following:
- Vaccination sites must store and handle COVID-19 vaccines under proper conditions, in accordance with the requirements provided in the professional information supplied by the manufacturer, as

well as any other policies and guidelines provided by the NDoH, including where applicable always maintaining cold chain conditions and chain of custody;

- Vaccination sites must monitor vaccine-storage-unit temperatures at all times using equipment and practices that comply with rules relating to good pharmacy practice and the National Cold Chain and Immunisation Manual 2015;
- Vaccination sites must comply with guidelines and reporting requirements for dealing with temperature excursions; as outlined in the National Cold Chain and Immunisation Manual;
- Vaccination sites must monitor expiry dates of COVID-19 and apply the FEFO principle (First expiry/First out);
- All records related to COVID-19 vaccine management must be maintained for a minimum period of five (5) years.
- Vaccination sites will monitor the vaccine wastage to identify any avoidable wastage and mitigate accordingly.
- Vaccination sites must comply with all requirements defined by the NDoH for disposing of COVID-19 vaccine and diluent, including damaged, expired and/or unused doses.
- Vaccine administration
- COVID-19 vaccines must be administered in accordance with the NDoH vaccine rollout framework relating to allocation and priority groups.
- COVID-19 vaccines must also be administered in accordance with all requirements and guidelines of the NDoH.
- Each vaccination session should be planned, to ensure that enough vaccinators, vaccines, ancillary items, and waste disposal containers are available.
- Before administering a COVID-19 vaccine, vaccination sites must ensure that consent is given for the COVID-19 vaccine to be administered to the recipient.
- Where access to COVID-19 vaccines is provided via section 21 of the Medicines Act informed consent should be ensured. (Note: provision for recording of informed consent could be included in the Electronic Vaccination Data System (EVDS)
- Where necessary, provision must be made to facilitate clients receiving the appropriate second dose of the COVID-19 vaccine administered.
- A mechanism must be in place to trace any recipients who default from receiving the 2nd dose.
- Vaccination sites must report all adverse events following immunisation (AEFI) using the process defined by the NDoH.
- Reporting
- After administering a COVID-19 vaccine, the vaccinator must record the details of the vaccine administered on the recipient's vaccine record, plus any other information required using the appropriate reporting tools.
- Vaccination sites must provide stock-on-hand information to the NDoH at least once a week or as per the schedule defined by NDoH, using agreed reporting systems and in the correct format.
- Vaccination sites must report the number of doses of COVID-19 vaccine and diluents (if required) that were unused, spoiled, expired, or wasted.
- If EVDS cannot be used on-site, for any reason (remote areas with no internet access), a paper-based system may be used, and data captured on the EVDS system at the district level.
- Training
- Vaccination sites must ensure that all persons delegated to administer COVID-19 vaccines are appropriately trained and competent to provide the service and are functioning within his/her scope of practice.
- Vaccination sites must ensure that all staff involved in the provision of COVID-19 vaccination services are appropriately trained to use the relevant reporting tools.
- Ancillary supplies

- Vaccination sites must maintain an adequate supply of ancillary items required to provide vaccination services.
- Vaccination sites must procure ancillary supplies as per standard procedures or specific procedures put in place by the NDoH or the applicable province.
- Waste disposal and management
- Injection equipment should be discarded immediately after use.
- Any unused vaccine or waste material should be disposed of in accordance with requirements.
- Injection equipment should be discarded immediately after use Vaccination sites must ensure safe disposal of used needles, syringes, and empty vials.
- Equipment used for vaccination, including used vials, ampoules or syringes, should be disposed of by placing them in a proper, puncture-resistant 'sharps box'
- AstraZeneca/SII COVID-19 Vaccine contains genetically modified organisms (GMOs). Sharps waste and empty vials should be placed into yellow lidded waste bins and sent for incineration; there is no need for specific designation as GMO waste.
- Each vaccination site will develop a waste disposal plan, which includes the name of the contracted waste disposal company, number of waste disposal containers available, number of red/yellow disposal bags available/ proof of regular waste disposal e.g., last destruction certificate
- How the waste disposal will be adapted to incorporate an increase in vaccination waste, which will include, empty/ opened vials, diluent, needles/syringes, and PPE

MINIMUM REQUIREMENTS

This guidance checklist will prepare the vaccination site to implement the required steps to provide the vaccine safely and efficiently.

General

- Vaccination sites are clean, and the area is not directly exposed to sunlight, rain, or dust.
- The vaccination site is well ventilated, and all fixed sites should be temperature controlled.
- Vaccination sites have space where clients can sit before being vaccinated.
- Vaccination sites have spaces for registration, screening, vaccinating, and recording.
- Vaccination sites require all necessary equipment and furniture to provide the vaccination services including desks, tables, and chairs.
- Vaccination sites must have appropriate waste disposal systems.

Reporting Systems

- Vaccination sites must have a computer or other device to report vaccination data using the EVDS.
- The computer or other device used for EVDS reporting must have appropriate connectivity to submit data.
- The vaccination site must provide stock-on-hand information to the National Department of Health as per the defined schedule and agreed reporting systems.
- It is recommended that the vaccination site make use of 1D and 2D Barcode scanners as far as possible for scanning barcodes and QR codes located on (Medical Vials, Green Barcoded ID Book, Drivers Licence, Smart ID and Passports etc) this will assist in accurate data collection into the EVDS System.

Vaccine storage

- Vaccination sites must have appropriate and sufficient cold chain storage capacity to comply with the manufacturers' vaccine storage requirements and to accommodate the volume of vaccine required to be stored at the provided to the site.
- Vaccination sites must have WHO PQS continuous temperature monitoring and logging devices to monitor the vaccines' storage temperature, which displays alarms, min/max temperatures, and a log of temperature readings.

- Vaccination sites must have alternative power sources to maintain the cold storage conditions in a power failure event.
- Vaccination sites will have a contingency plan which include alternative storage locations if the cold storage unit fails, transport to such a facility, suitable passive containers to transport the vaccine to the specified site.

Vaccine redistribution

- Vaccination sites required to redistribute vaccines to another site must have a documented process, which complies with National Cold Chain Manual, to perform this activity.
- For redistribution purposes, the Vaccination site must have appropriate validated packaging that will maintain the temperature of vaccines during redistribution at the temperature indicated by the manufacturer.
- For redistribution purposes, the vaccination site will ensure each active/passive container will have a WHO PQS continuous temperature monitoring device during distribution/ storage of the vaccine

Inventory management

- Vaccination sites must have an inventory management system, including bin cards or electronic stock management systems to manage vaccines and ancillary supplies.
- Number of doses required = session size (target population) x wastage factor (15% = 1.11)
- Number of vials required = number of doses required / number of doses per vial (e.g.,10 dose)

Ancillary supplies

Ancillary supplies may vary depending on the type of COVID-19 vaccine. Vaccination sites must maintain an adequate supply of the following ancillary supplies:

- Syringes for vaccination: 1ml or 2ml (1 syringe per dose)
- Needles suitable for intramuscular vaccination: 22-25G and 25mm-38mm (1 needle per dose)
- Syringes for reconstitution - 5ml ***(if required)*** (1 per vial)
- Needles for reconstitution- 21G ***(if required)*** (1 per vial supplied)
- Diluent for reconstitution (if required and if not provided by the manufacturer) (1 per vial supplied)
- Cotton wool balls (1 per number of vaccine recipients)
- A safety box for disposal of used syringes and needles (1 per 100 doses supplied)
- Hydrogen Peroxide disinfectant*
- PPE as outlined in infection control guidelines

*Vaccine spills should be disinfected with an appropriate antiviral disinfectant (e.g. Hydrogen peroxide-based disinfectants).

Other supplies

- Case reporting form (CRF) for reporting AEFI
- Case investigation form (CIF) for investigating serious AEFI
- Case investigation forms for adverse events of special interest (AESI)
- Stock cards/bins cards (if not using an electronic stock management system)
- Vaccination cards
- Tally sheets or relevant recording form/tool
- Fact sheets
- Posters
- Job aids

Emergency supplies

- Adrenalin Injection (1:1000) solution – 2 ampoules
- Hydrocortisone injection (100 mg) -1 vial
- Syringes
- Needles
- IV fluids, (Ringer- Lactate solution or normal saline) with drip set

- AEFI reporting form

DECLARATION

☐I hereby declare that the vaccination site complies with the requirements stated in this document, including all relevant legislation and the rules relating to Good Pharmacy Practice.

☐I acknowledge that representatives of the District or Provincial Departments of Health may inspect the vaccination site from time to time to confirm compliance.

Chapter 13: Leveraging the Go.Data Digital Platform for COVID-19 Epidemiological Surveillance: Case of the Free State, South Africa

Ntombela, B.,[1] Heunis, J.C.,[2] Chikobvu, P.,[3,4] Muteba, M.,[5] Tshilo, T,[4] and Lenyehelo, T.[4]

[1]Information, Communication & Technology, Free State Department of Health (FSDoH);
[2]Centre for Health Systems Research & Development, University of the Free State (UFS);
[3]Department of Community Health, UFS; [4]Information Management & Research, FSDoH;[5]World Health Organisation;

Purpose: *In March 2020, the first COVID-19 case was reported in South Africa, and a series of measures were enacted that excluded standardised outbreak surveillance and reporting mechanisms, prompting provinces to establish their own. The World Health Organisation (WHO) recommended Go.Data, an outbreak investigation tool for field data collection during public health emergencies, which the Free State Department of Health (FSDoH) adopted. This chapter outlines the implementation process of the Case-Based Surveillance System (CBS), Go.Data and its application in monitoring the COVID-19 pandemic in the Free State province, emphasising both the challenges encountered and successes attained.*

Study approach: *This chapter offers a qualitative retrospective description of the Go.Data implementation process employs an implementation science research methodology in conjunction with relevant business processes. The WHO conducted virtual training sessions on Go.Data for essential health and information management personnel, followed by pilot testing in the Xhariep district. District-specific engagements and training sessions aimed to foster buy-in among stakeholders. Live COVID-19 surveillance activities were seamlessly integrated into Go. Data, including case investigation and contact tracing. Each district appointed a dedicated Go.Data champion to oversee implementation and ensure daily reporting.*

Findings: *The implementation and use of Go.Data enhanced the technological proficiency of healthcare professionals and provided real-time access to high-quality COVID-19 data. By 31 March 2022, Go.Data had reported 207,829 cases with 30,394 admissions. Following the FSDoH's positive experience, additional provinces adopted Go.Data.*

Originality/value: *Developing business processes within existing structures and establishing rapid response teams at the lower levels of care provided efficiency in pandemic management in the Free State. The adoption of Go.Data enabled a seamless, effective CBS procedure that increased data quality, timely reporting and more effective pandemic response by the FSDoH.*

Keywords: *Go.Data, Case-based Surveillance, Outbreak, COVID-19, Case-Based Surveillance System, Digitisation*

13.1 Introduction

Although it was initiated prior to the onset of COVID-19, the National Digital Health Strategy for South Africa 2019-2024 (NDoH, 2019) prioritised a patient-centred approach, emphasising a fundamental transformation in health information systems design from traditional patient monitoring for reporting to Case-Based Surveillance (CBS) (National Department of Health [NDoH], 2019). While patient monitoring primarily gathers aggregated epidemiological and management data, CBS necessitates data collection that supports clinical decision-making and patient education. This chapter recounts using Go.Data to leverage a digital CBS platform for COVID-19 in a South African province. Developed and recommended by the World Health Organisation (2024), Go.Data is an outbreak investigation tool for field data collection during public health emergencies. The tool includes functionality for case investigation, contact follow-up, visualisation of chains of transmission, including secure data exchange. It is designed for flexibility in the field, to adapt to the wide range of outbreak scenarios.

A scoping review conducted by Silenou (2021) identified four primary tools: Surveillance Outbreak Response Management and Analysis System (SORMAS), Go.Data, CommCare, and District Health Information System 2 (DHIS2). These tools collectively encompass a comprehensive range of attributes necessary to provide integrated digital support for epidemic control, particularly during events such as the COVID-19 pandemic. The functional capabilities of these tools include critical features such as laboratory interface integration, contact tracing, and visualisation of transmission networks.

This chapter focuses on the Free State Department of Health's (FSDoH) adoption, implementation, and utilisation of the Go.Data platform for managing COVID-19 Case-Based Surveillance (CBS) in the Free State province. It describes the implementation process of Go.Data and its application in monitoring the COVID-19 pandemic, highlighting both the challenges encountered and the successes achieved. The chapter employs a qualitative retrospective approach to detail the implementation of Go.Data, integrating methodologies from implementation science and relevant business processes.

13.2 COVID-19 and the South African Government’s Response

The global emergence of the coronavirus began in December 2019 in China (Zhu et al., 2020; Cheng et al., 2023), leading to a rapid spread that left most countries unprepared for this novel infectious disease. The WHO declared COVID-19 a public health emergency of international concern in January 2020 (Zhu et al., 2020; Cucinotta & Vanelli, 2020) and referred to it as a global

pandemic in March 2020 (Cucinotta & Vanelli, 2020). On 30 March 2020, the South African President announced a National State of Disaster, in terms of Section 27(5)(c) of the Disaster Management Act, 2002 (Act 57 of 2002), in line with the WHO principles of outbreak response and transmission mitigation. Despite the mitigation strategies by the President, an effective surveillance monitoring and reporting system was notably absent. Consequently, provinces were compelled to hastily develop their own surveillance systems. Nationally, provinces resorted to using Excel spreadsheets to collate data from multiple sites, which were transmitted via cell phone or WhatsApp messages by rapid response teams scattered across different locations. In the Free State, data on COVID-19 cases and contacts were initially collected on paper and later aggregated in Excel, which hindered the timely use of data for informed decision-making at various levels of pandemic response. Moreover, the absence of assured data quality (in terms of accuracy, completeness, and consistency) posed challenges, limiting the effective application of data governance frameworks and reliability checks.

Figure 13-1 depicts the transmission chains and contact flow observed in the Free State. For instance, Case A had contact with four individuals who subsequently contracted the disease, resulting in two of them becoming confirmed cases. These contacts further transmitted the virus to others they interacted with, subsequently establishing transmission chains that required interruption through rigorous contact tracing and the isolation of cases and contacts.

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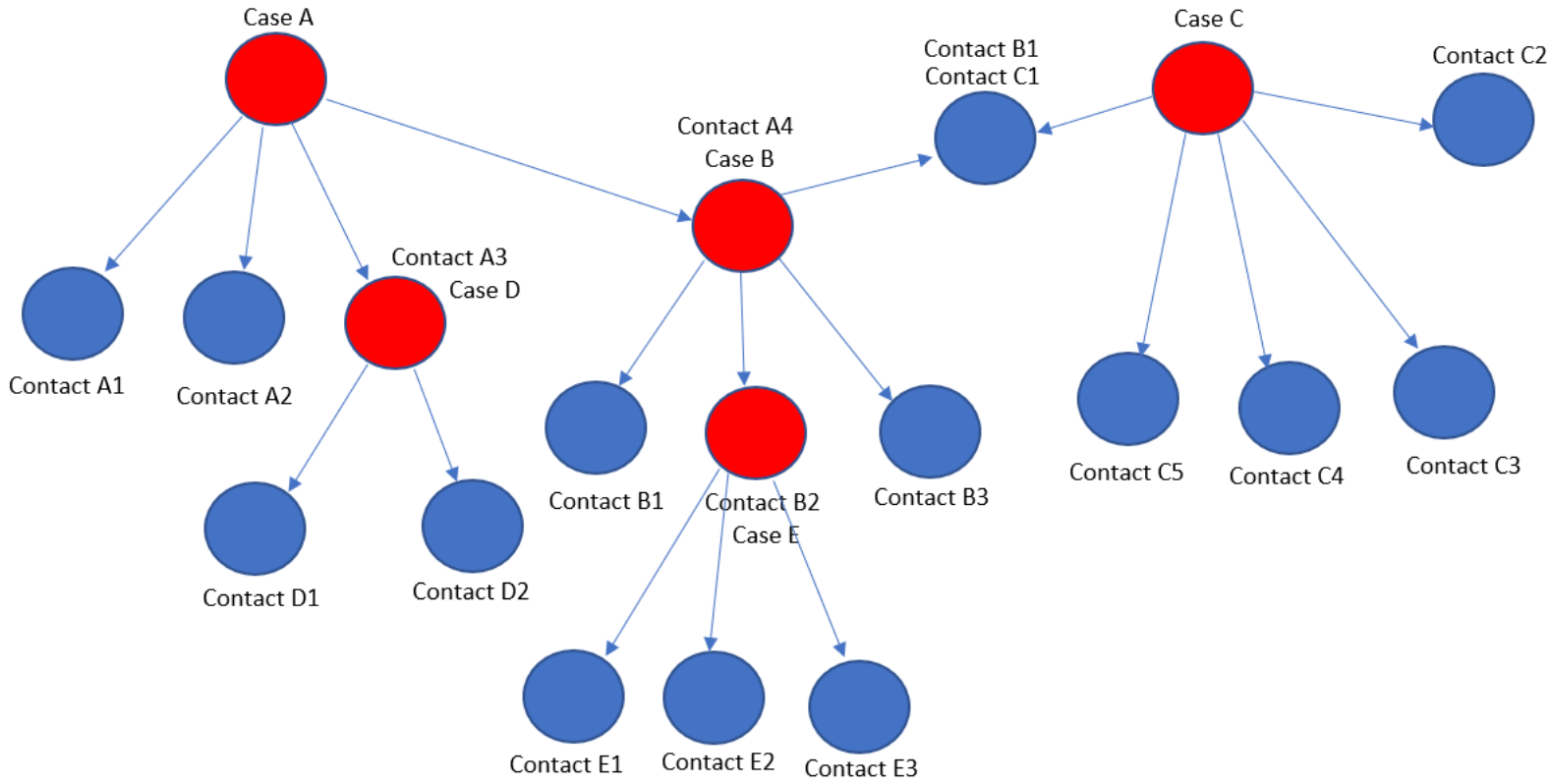

Figure 13-1: COVID-19 transmission and contact flow

13.3 COVID-19 Outbreak and Response in the Free State Province

The Free State Province is situated in the central region of South Africa and is one of the country's nine provinces. It comprises four health districts and one metropolitan municipality, totalling 21 subdistricts (Figure 13-2). The province spans an area of 129,825 km², with a population of 2,964,412 and a population density of 22.83/km² (Statistics South Africa, 2022) (Figure 13-2). The province reported its first positive COVID-19 cases in March 2020. For a rapid response, the province's COVID-19 response was centrally coordinated by establishing the Provincial COVID-19 Command Centre (PCCC), which met daily to discuss progress in mitigating the pandemic and necessary strategic changes. This centralised response and decision-making approach coordinated all levels of the response within the province. The centralised response resources included the University of Free State, one academic hospital, and one tertiary hospital, all located in the Mangaung Metropolitan Municipality and near the Provincial Health Head Office. The approach established five different streams: 1) case identification, 2) case investigation, 3) contact tracing, 4) contact monitoring, and 5) case monitoring by clinical professionals and the data analysis team. These streams were tasked to handle the outbreak centrally.

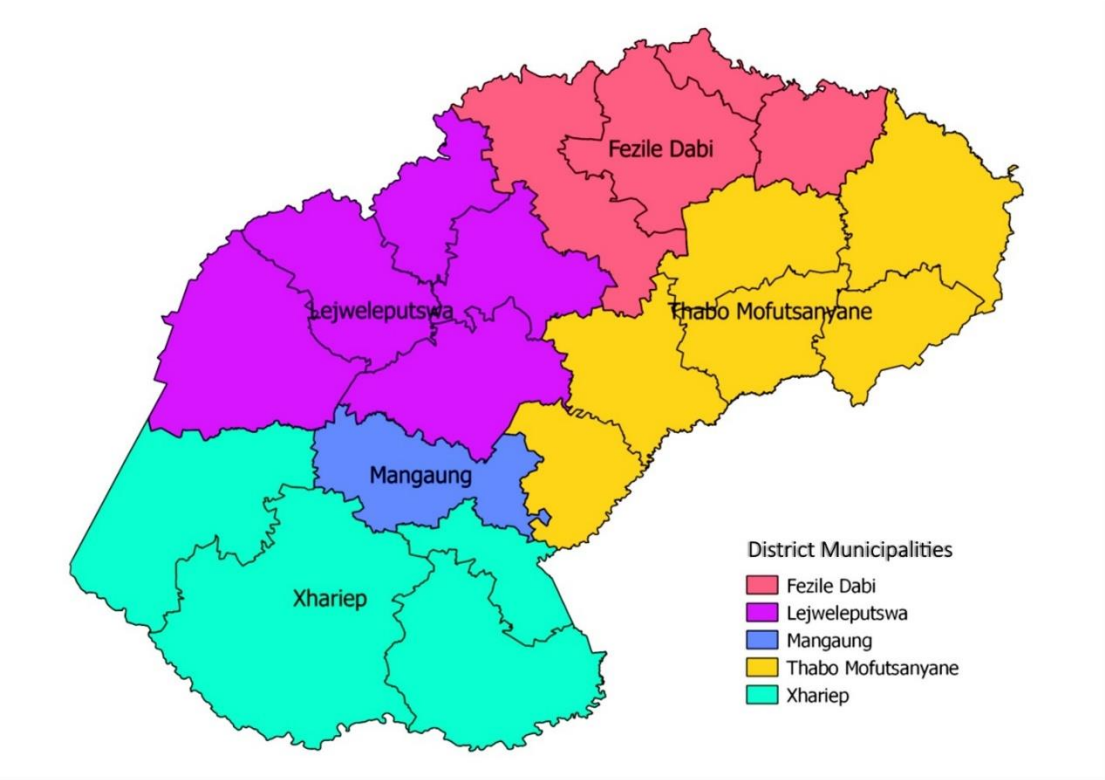

Figure 13-2: District municipalities in the Free State

The PCCC operated as an authority that vertically commanded the response through all health structures at all levels of care. It coordinated the technical expertise and specialised support

provided by the various institutions and partners, including the WHO, to ensure a united effort. With the rapid spread of the disease, the Free State province conducted COVID-19 testing daily, and mobile testing laboratories were stationed in strategic points to test as many people as possible. Initially, the province established two call centres for contact tracing. However, the disease spread rapidly, giving rise to clusters and hotspots, with chains of transmission becoming increasingly extensive (Figure 13-1). The rapid response teams documented their investigations and monitoring information on paper, which was subsequently entered into Excel spreadsheets. This process was cumbersome, resulting in a delay of approximately 14 days, and led to some cases being overlooked due to the time-consuming back-capturing of information and manual consolidation. Monitoring these activities on paper posed significant challenges for FSDoH management.

Despite the swift initial response to the first cases and clusters, the Free State province faced the challenge of ensuring sufficient capacity across its districts and subdistricts to effectively manage the COVID-19 pandemic, given their pivotal role in outbreak control. The province's five districts vary significantly in population size, density, availability of implementing partners, access to expertise from academic institutions, and the distribution of healthcare facilities between urban and rural areas. In order to achieve a more targeted and nuanced response, decentralising the response function to lower levels of management and care was deemed essential. The WHO played a critical role in facilitating this decentralisation of pandemic response structures, thus facilitating smoother implementation. This initiative required a robust digital outbreak information management system to replace outdated paper-based systems.

Using Go.Data, the Free State province decentralised COVID-19 data management with support from partners, employing principles of implementation science. The authors propose that insights gained from the Free State's experience could provide valuable lessons for improving public health disaster management in resource-constrained healthcare systems across sub-Saharan Africa.

Given the limitations of existing routine systems in managing outbreaks, the Free State province could not repurpose or utilise existing digital routine surveillance technologies to support COVID-19 pandemic data management effectively. Consequently, a pressing need arose for implementing a digital platform capable of managing a comprehensive COVID-19 outbreak database. Such a platform would provide real-time, high-quality data for rapid decision-making, efficient data management, thorough case investigation, comprehensive contact tracing, and effective case monitoring. Additionally, a real-time dashboard would be instrumental in visualising transmission chains within the Free State province.

As the province grappled with escalating case numbers and contacts, it became apparent that delays in investigating some cases hindered the timely tracing and quarantine of their contacts. A primary factor was the reliance on manual surveillance monitoring through a paper-based system. In some instances, case record forms (CRFs) failed to reach data entry clerks promptly, undermining the progress achieved when initial clusters were swiftly investigated and transmission chains promptly

disrupted. Consequently, the provincial leadership initiated a team to explore the feasibility of implementing a *case-based digital outbreak surveillance tool*. This tool aimed to enhance the generation of high-quality data and real-time monitoring of activities by rapid response teams across various levels of the response effort.

13.4 Managing Pandemics Using Go.Data

Prior to COVID-19, digital pandemic monitoring tools had been deployed in Africa for managing Ebola outbreaks, while in Europe, apps were used for contact tracing during the pandemic (Mirugwe & Kibanga, 2023). Go.Data, developed by the Global Outbreak Alert and Response Network (GOARN) coordinated by WHO, is a comprehensive tool for collecting and managing data on confirmed cases, probable cases, suspects, and their contacts. It facilitates daily follow-ups on contacts, identifies symptomatic contacts, monitors contact tracing performance at the national and district levels, and visualises transmission chains (WHO, 2020). In addition to its role during COVID-19, Go.Data has been utilised to manage outbreaks such as measles in Brazil and various infectious diseases, including Hantavirus, tuberculosis, leprosy, and measles in Argentina (WHO, 2022). Although connectivity issues limited real-time data provision in Uganda, Go.Data was effectively employed during the Ebola pandemic (Mirugwe & Kibanga, 2023). In the Democratic Republic of the Congo, Go.Data significantly enhanced contact tracing performance for Ebola virus disease in 2019 (WHO, 2020; Mobula et al., 2020). In addition to Go.Data, other mobile health applications and business intelligence software were used to collect and analyse Ebola contact tracing data in Guinea. The system offered the potential to improve data access and quality to support evidence-based decision-making for the Ebola response (Sacks et al., 2015). However, the authors cited some implementation challenges, such as software limitations, technical literacy of users, coordination among partners, government capacity for data utilisation, and data privacy concerns.

While major developments in Go.Data functionality addressed some key gaps highlighted during the Ebola pandemic, continued dialogue between WHO and implementors, including cross-country experience sharing, is needed to ensure the tool is reactive to evolving user needs. A study conducted by Hollis et al. (2023) demonstrated that Go.Data was a useful complement to responses across diverse contexts and helped set a reproducible foundation for future outbreaks. Concerted preparedness efforts across the domains of workforce composition, data architecture and political sensitisation should be prioritised as key ingredients for future Go.Data implementations.

13.5 Study Approach

This section outlines the study approach regarding 1) the acquisition of a digital platform, 2) the implementation plan, 3) the implementation process using implementation science methods, 4) digital transformation, 5) piloting, 6) Go.Data deployment in other districts, 7) training, 8), data hosting and system maintenance, 9) the district surveillance monitoring team, and 10) daily receipt of COVID-19 case information on Go.Data.

13.5.1 Acquiring a Digital Platform

Recognising the need for a digital tool that would provide real-time, high-quality CBS data for monitoring the pandemic, the Head of the Department (HoD) and other senior managers sought a solution to enable quick, informed decision-making and planning regarding response strategies to the rapidly increasing number of transmission hotspots and changing disease patterns (FSDoH, 2024). This necessitated the implementation of a robust digital outbreak data management system. Despite being approached by several vendors marketing ready-made health information systems prior to the COVID-19 outbreak, the FSDoH found itself without a system available to support the COVID-19 response when the pandemic started. While one institute of higher learning attempted to utilise Microsoft Access for data collection to support the FSDoH, this solution proved inadequate due to the need for multiple simultaneous activities and real-time pandemic data to effectively plan strategies to curb COVID-19 transmission chains. Without a suitable CBS system, the WHO recommended Go.Data, an open-source web-based outbreak data management system. Subsequently, Go.Data was adopted as the principal system for COVID-19 CBS in the Free State province (FSDoH, 2024). Developed by the WHO, in collaboration with the Global Outbreak Alert and Response Network (GOARN), to manage complex data related to infectious disease outbreaks, such as Ebola and COVID-19, Go.Data allows simultaneous management and monitoring of activities at all levels of care.

Figure 13-3 depicts the integrated COVID-19 management framework facilitated by Go.Data in the Free State province. Go.Data played a pivotal role in real-time pandemic management, encompassing case investigations, monitoring, contact tracing, comprehensive data management, report generation, and real-time activity monitoring, which is crucial for breaking transmission chains. The figure delineates A) activities for case identification, B) strategies for case management, C) pandemic monitoring protocols, and D) leadership and administrative roles, highlighting the holistic approach to managing the pandemic effectively.

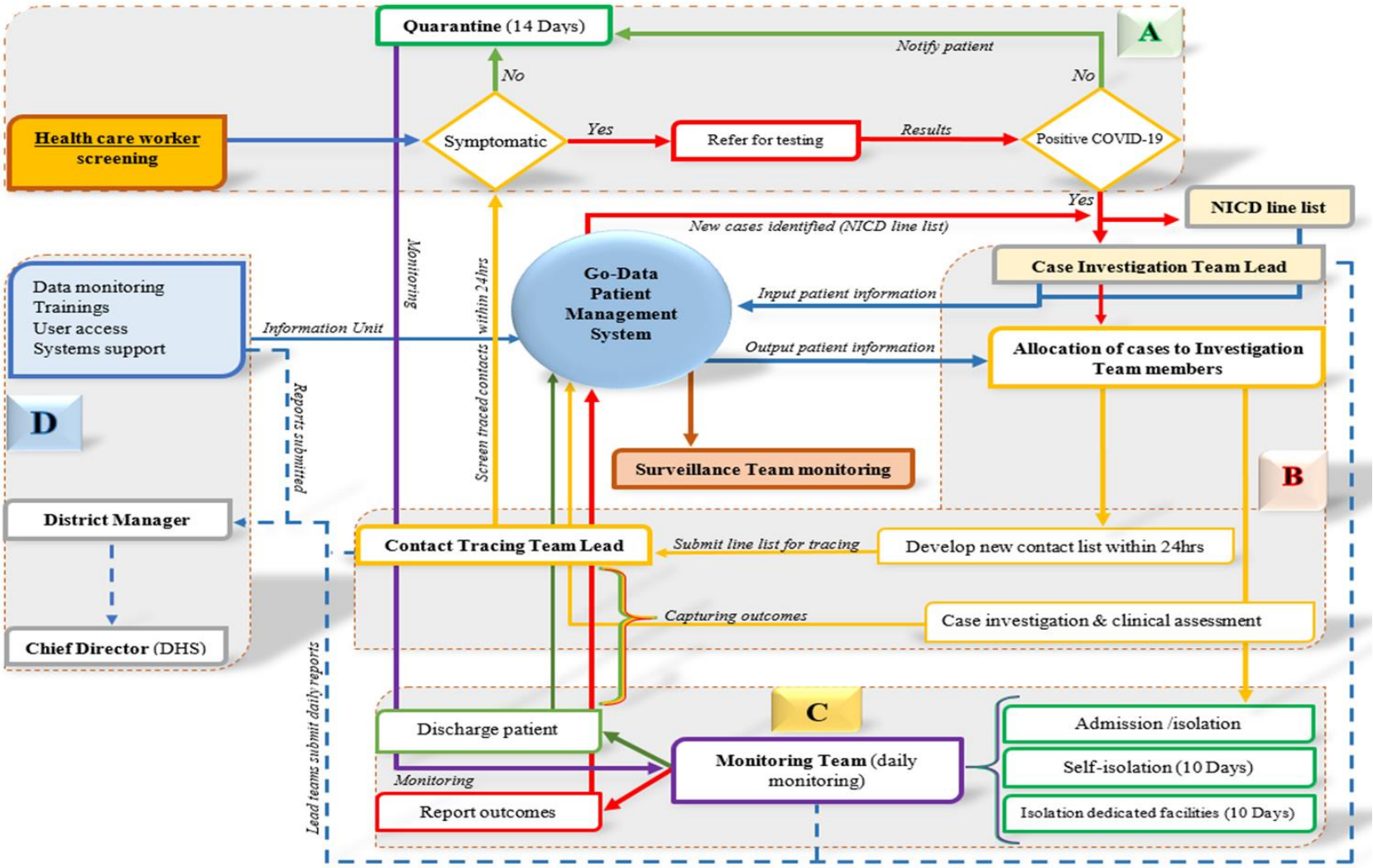

Figure 13-3: Holistic interaction of the COVID-19 management activities in Go.Data usage in the Free State Province (FSDoH, 2024)

Healthcare workers (HCWs) conducted COVID-19 screenings within the community and at gatherings. Individuals displaying symptoms were referred for testing at the nearest testing site. Positive results were promptly added to the National Institute for Communicable Disease (NICD) COVID-19 list for the Free State. Any new positive cases not yet recorded in Go.Data were imported into the system and assigned to respective districts for investigation. District-specific case investigation teams accessed these cases through Go.Data to conduct real-time investigations and compile lists of contacts for each case. Subsequently, district-specific contact tracing teams received these lists and initiated tracing activities based on information from the case investigations teams. Progress on case investigations was monitored continuously, with outcomes recorded in real-time within Go.Data. Line managers were given real-time access to management dashboards, enabling them to monitor activities such as case investigation, contact tracing, and case monitoring. Comprehensive reports were readily available to district management, the district health service chief director, and the provincial surveillance team, and daily reports were seamlessly submitted to the NDoH (FSDoH, 2024). The implementation of the Go.Data system significantly supported Free State health authorities in collecting, managing, and analysing data on cases, contacts, and other pertinent information during the outbreak. It streamlined contact tracing efforts and effectively contributed to interrupting chains of transmission of contagious diseases.

While implementing Go.Data stages, Obukhova et al. (2020) outlined for introducing technology into an enterprise (Figure 13-4) were adhered to. The enterprise refers to the province's COVID-19 response environment, encompassing healthcare facilities and communities. The necessity for digital transformation in managing the outbreak was evident, with expectations of significant improvements in processes, workflows, and the overall pandemic management structure of the FSDoH (Bonnet & Nandan, 2011; Fitzgerald et al., 2013). The primary objective of digitising the outbreak information management was to enhance response speed, elevate data quality, and mitigate the spread of infection. Go.Data was systematically integrated as the singular COVID-19 management system and the primary source of pandemic-related data. Its adaptability promised to enhance CBS efficacy and facilitate simultaneous execution of all COVID-19 pandemic management activities, including investigation, contact tracing, and case monitoring.

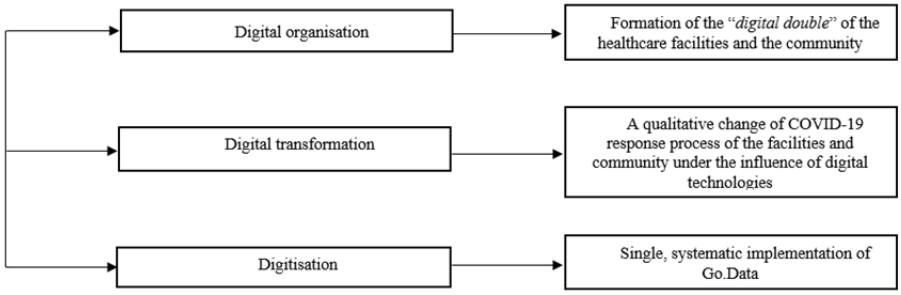

Figure 13-4: Stages of the introduction of digital technology in response to COVID-19 (Adapted from Obukhova et al., 2020:4)

The goal was to transform pandemic management in the Free State province digitally and to achieve an elevated level of efficiency in dealing with rapid changes in transmission hotspots and movement of the chains of transmission, including robust containment processes. In addition, the transformation was intended to meet the increasing demands for rapid response teams as well as increase the flexibility, transparency, and monitoring of the pandemic management activities at all levels of health care and in the community. Furthermore, it was anticipated that the digitisation of outbreak response would guarantee the rapid breaking of chains of transmission, as this allowed leadership monitoring to address challenges at all levels of response rapidly. In the digital transformation process, the province went through stages of qualitative change, which were reflected in the improvement of response processes and the availability of real-time data. This also improved the quality of information on the pandemic management activities, allowing adaptation to changes in the spread of the disease and process flows, including an adaptation of the collected variables and real-time data consolidation for analysis.

Challenges arose related to the digitalisation of the COVID-19 outbreak management due to the speed and scale of the required changes to customise Go.Data amidst a pandemic. Acquiring Go.Data was a practical activity of the Free State province, considering modern technological requirements and a qualitative change in the business processes of the rapid response teams, management practices and integration of the digital ecosystem of the province, together with partners involved in the value chain (Matt et al., 2015).

The Free State province needed to customise the CRFs within the system with the possibility of an interactive exchange of ideas and developments based on the development of the disease's patterns. In addition, the province needed the capacity and expertise to host the data. The leadership of the FSDoH and the political head, supported by partners, facilitated stakeholder engagement and user buy-in. The FSDoH acquired Go.Data and implemented this solution as a CBS for COVID-19 pandemic monitoring.

13.5.2 Implementation Plan

The implementation plan was developed with an understanding that digitalisation, in this case, meant the modern stage in rapid use of outbreak management digital technologies for the generation, processing, transmission, storage and visualisation of outbreak information, including rapid dissemination of new hardware and software solutions (Obukhova et al., 2020, p. 2). The other binding principles included 1) the need for reliable and accurate data for decision-making, 2) the decisiveness of leadership and adoption of the principle of moving fast with no regrets, and 3) because the Free State province had functional, well-coordinated structures, piloting and scaling up Go.Data followed suit. Table 13-1 presents a summary of the implementation plan that was followed.

Table 13-1: Summary of the Implementation Plan

Activity	Members	Roles
Establish a Provincial Technical Oversight Committee (PTOC)	HoD and DDG Clinical Services Provincial response leadership Other relevant senior managers WHO team University of the Free State team Right to Care team	Putting together a deployment plan and relevant structures at various levels of response Provide implementation oversight Monitor Go.Data implementation progress weekly Request additional resources for implementation from the partners Unlock implementation challenges Champion stakeholder engagement and buy-in from the district management teams Monitor outbreak management daily
Establish implementation team	Asset management team Information and communication technology (ICT) team Information management team WHO team Right to Care team	Distributing the required hardware to the rapid response teams Computer literacy training and preparing assets for use Training on the use of the system and providing user credentials for distinct roles
Establish district management teams	All the current district management team members Go.Data champion Support partners	Support Go.Data implementation Constantly monitor Go.Data usage Monitor emerging hotspots and chains of transmission Liaise with the PTOC and guide the rapid response teams Champion stakeholder engagement and facilitation of buy-in from the users Monitor case investigation and contact tracing activities within the district Report progress daily on outbreak management within the district Daily monitoring of data completeness Unlock user challenges Implement change management supported by the implementation team
District rapid response teams	Healthcare professionals from the FSDoH and its partners	Case investigation Contact tracing Monitoring disease progress among cases
Subdistrict rapid response teams	Healthcare professionals	Case investigation Contact tracing Monitoring disease progress among cases
Go.Data implementation timeline	Asset management team ICT team Information management team WHO team Right to Care team	Develop implementation timeline Share the timeline with the district management team

The tasks that different implementation participants embarked on were as follows (FSDoH, 2024):

- Implementation of Go.Data was technically and financially supported by partners, the leadership of the FSDoH, and the Political Head of the Department.
- The Provincial Technical Oversight Committee (PTOC) was established to develop a

deployment plan and relevant structures at different response levels. These included the district management teams with a Go.Data champion nominated for each district who received thorough training about the system.

- The implementation plan was developed by the implementation team reporting to the PTOC.
- The district directors accepted the deployment of the system immediately since it would be possible for them to monitor the activities of the rapid response teams, including monitoring chains of transmission, in their districts.
- Regarding policy guidance/changes, a standard operating procedure (SOP), memos and instructions were sent from the provincial to the district levels with clear actions and timelines regarding training, data capturing, preparation, and submission of reports.
- Concerning implementation monitoring, the Go.Data tool was used at the provincial and district levels to monitor user activity. The PTOC constantly provided the needed support to the users and continuously modified the CRFs on the system as required by the PTOC.
- Any challenges were reported to the PTOC chaired by the HoD for their action; regular meetings with district managers were conducted to discuss progress and challenges.
- The leadership drove change management to support the transition from a paper to a digital system at the province, district, and subdistrict levels, which was paramount for the project's success. This involved skills gap analysis and activation of training on the use of computers, followed by training on the use of the Go.Data system by all the rapid response teams at each level. Initially, there was resistance to using the system, especially by older healthcare professionals, which can probably be ascribed to *fear of the unknown*.
- Stakeholder engagement and buy-in were incorporated into the implementation process since there was a demand to implement the system rapidly. This was driven by the PTOC and the district management teams supported by the implementation team.
- User support platforms included WhatsApp groups, and online technical support was available twenty-four hours a day, seven days a week, to support users.
- Regarding the community of practice, weekly meetings were held to discuss challenges for learning purposes and to share knowledge and successes for adopting in other areas where the challenges persisted.
- Partner support entailed Right to Care, the WHO, and the University of the Witwatersrand RHI supporting FSDoH with the redeployment of information and communication technology (ICT) equipment and human resources (HR).
- WHO (Geneva) provided online master trainer training on the software and how to modify the CRFs and customise Go.Data on the Free State province’s needs. They also provided data hosting training and continuous support to the ICT teams.

13.5.3 Implementation Process Using Implementation Science Methods

This section offers a qualitative retrospective on the implementation of the Go.Data system, employing an implementation science approach akin to Hamilton et al. (2019). The PARiHS Framework was applied to facilitate practical integration and institutionalise the utilisation of Go.Data within healthcare facilities in the Free State.

The Quality Enhancement Research Initiative (QUERI) was established in the late 1990s within the U.S. Veterans Health Administration to drive research-based initiatives to enhance healthcare quality and advance implementation science (Stetler et al., 2008). Over time, the limitations of QUERI led to the evolution of the PARiHS framework, as documented in various studies (Kitson et al., 1998; Rycroft-Malone et al., 2002; Rycroft-Malone et al., 2004). PARiHS was developed to address the complexities inherent in translating evidence into practice. Scholars have recognised PARiHS as a valuable theoretical and practical tool for guiding research and practice development (Meijers et al., 2006; Wallin et al., 2006; Bergström et al., 2020).

Kitson et al. (2008) emphasised that PARiHS captures the intricate dynamics of implementing evidence into practice. Originally, PARiHS was represented by the equation SI = f(E, C, F), where SI denotes successful implementation, f signifies the function of, E stands for evidence, C represents context, and F denotes facilitation. However, critics such as Harvey and Kitson (2016) pointed out that the concept of successful implementation lacked a clear definition within the field of implementation science. Moreover, as a conceptual framework, PARiHS requires further refinement, particularly in the context of digital innovations in healthcare services within implementation science.

Kitson et al. (2008) underscored that the PARiHS framework is a valuable practical and conceptual tool for translating research into practice. However, its impact on implementation science remains to be empirically quantified. Recognising the limitations of PARiHS, Harvey and Kitson (2016) introduced a revised framework known as integrated PARiHS (i-PARiHS). This updated version incorporates specified implementation targets and considers the broader external context (social, political, policy, and economic factors) influencing implementation while refining the concept of successful implementation (SI) to denote the achievement of agreed-upon implementation or project goals. Despite these advancements, the framework has not fully addressed digital and technological interventions. The authors highlighted areas for future research and development, including testing the utility, applicability, and validity (both content and construct) of i-PARiHS in various contexts.

The fundamental elements of both the PARiHS and i-PARiHS frameworks – specifically facilitation, innovation, recipients, and context – are outlined in Table 13-2, with facilitation serving as the active component that evaluates, aligns, and integrates the other three constructs. In applying implementation science in the Free State, certain concepts, such as successful implementation (SI), as defined in i-PARiHS, were integrated. This encompassed the adoption and

integration of the innovation into practice and engagement with individuals, teams, and stakeholders, fostering motivation and a sense of ownership towards achieving agreed-upon implementation or project goals (Harvey & Kitson, 2016).

Table 13-2: Revised PARiHS framework for a task-oriented approach to implementation: SI = function of E, C, F (Adapted from Stetler et al., 2011; Harvey & Kitson, 2016)

Element	Sub-element
E: Evidence and evidence-based practice (EBP) characteristics	Research and published guidelines: Go.Data has been successfully used in other settings, improving contact tracing and reducing chains of transmission. Local practice information: Manual system was being utilised to manage the pandemic, which was not helpful as data availability had a lag of about two days. Characteristics of the targeted EBP: Availability of real-time data, rapid case investigation and contact tracing, and rapid breaking of chains of transmission were considered. Relative advantage: Better management of the pandemic based on timely informed decisions. Observability: Rapid increase in COVID-19 cases in the province, emanating from church gatherings, among others. Compatibility: Go.Data was to provide the best capabilities aligned with pandemic management. Complexity: Rapid spread of COVID-19 made its management exceedingly difficult and complex. Trialability: Use of Go.Data would enable proper accountability for all the identified cases. Design quality and packaging: Implementing Go.Data facilitates real-time management of the entire COVID-19 pandemic, enabling concurrent live oversight and daily management. Costs: WHO donated Go.Data (including the implementation accessories) to the Free State.
C: Contextual readiness for targeted EBP implementation	Leadership support: Leadership provided crucial support and drove the implementation process, bolstered by strong political commitment. Culture: Go.Data was meant to improve COVID-19 pandemic management to reduce its harm to the community. Evaluation capabilities: These were intricately tied to key disease spread outcomes, including new case rates, recovery rates, and mortality statistics. Receptivity to the targeted innovation/change: All the response teams accepted the implementation of Go.Data as this would eliminate the time-consuming manual system.
F: Facilitation	Purpose, external and/or internal role: Enabled communication and marketed the capabilities of Go.Data. Expectations and activities: Focused change management activities for the Go.Data users and training on the use of the system. Skills and attributes of facilitator: These included conducting site-specific diagnostic assessments and drawing upon relevant sources such as prior research, literature, and supplementary theories to guide implementation interventions. Related to E: Conduct research to understand Go.Data software capabilities, user access, and how each category can utilise it. Related to C: Understanding how to adapt to the users' needs as these kept changing as the pandemic evolved.
SI: Successful implementation	Implementation plan and its realisation: The plan was developed and utilised during the implementation as indicated in the table including the development of district-specific plans. EBP innovation uptake: Team members were eager to utilise the Go.Data as this would reduce the workload. Patient and organisational outcomes achievement: The province improved the recovery rate, reduced the number of cases, and reduced the death rate.
From PARiHS to i-PARiHS	
'Successful implementation'	'Successful implementation' in the revised i-PARiHS framework.

Element	Sub-element
in the original PARiHS framework	
SI = *f*(E,C,F) SI = successful implementation *f* = function (of) E = evidence C = context F = facilitation	SI = f (I + R + C) where I = innovation, R = recipients, C = context SI = successful implementation Achievement of agreed implementation/project goals: Go.Data implementation goals were achieved, including the availability of real-time data, accurate data, monitoring of cases, rapid contact tracing, and breaking of chains of transmission. The uptake and embedding of the innovation in practice: At the end of the pandemic, Go.Data was embedded into practice as part of the routine data management process. Individuals, teams and stakeholders are engaged, motivated and 'own' the innovation: HCWs utilised Go.Data whenever they needed COVID-19 data, or when there were cases to be investigated. Variation related to context is minimised across implementation settings: Implementation of Go.Data was collected systematically and standardised across the province. Facilitation: Required change was expected to be brought about through change management training, marketing of Go.Data and the provision of training on the use of the system to all the users, including pulling reports. Innovation: The Go.Data tool was utilised for case investigations, contact tracing, and visualisation of transmission chains and hotspots. Recipients (individual and collective): These included all the HCWs and the COVID-19 patients, who were regarded as the beneficiaries of the Go.Data tool. Context (inner and out): The pandemic environment encompasses both health service delivery settings and the broader community context.

Based on the PARiHS framework, the facilitators drove the change management process. The change management process of Go.Data implementation followed the phases of change management processes outlined by Majdalawieh (2019) (Figure 13-5).

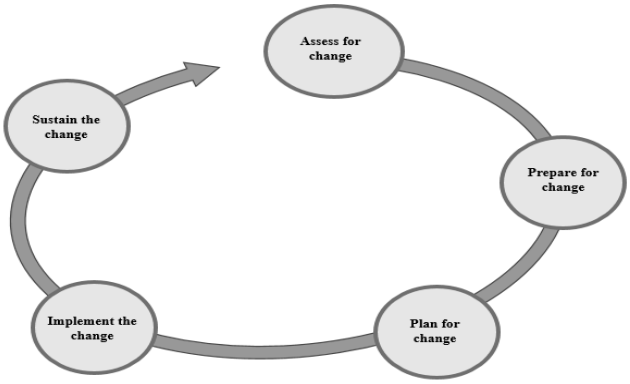

Figure 13-5: Change management phases (Adapted from Majdalawieh (2019, p. 443))

As recommended by Wensing (2015), the Go.Data implementation strategies were tailored to the target population (COVID-19 rapid response teams), setting (facilities and communities) and goals for improving the outbreak management and monitoring—the Go.Data implementation team

concentrated on evaluating several key outcomes: the feasibility, acceptability, appropriateness, and sustainability of Go.Data. They assessed its adoption and integration into the existing paper-based system, considering the sustainability factors, such as the availability of financial, human, and material resources provided primarily by supporting partners. The implementation process occurred concurrently with the existing paper-based system in certain districts, following an incremental approach encompassing the evaluation process (Proctor et al., 2011; Hamilton & Finley, 2019). Table 13-3 outlines Free State Province's implementation outcomes and how they aligned with implementation questions of interest for Go.Data, using a tabular approach, which is common in implementation science.

Table 13-3: Implementation outcomes and questions (Adapted from Hamilton and Finley, 2019))

Implementation outcome	Outcome definition	Aligning implementation questions with implementation outcomes
Feasibility	The extent to which Go.Data can practically be used in facilities and the community.	How do we ensure the execution of all the activities of the five different streams* simultaneously? Is this feasible within different configurations of primary care and communities?
Acceptability	Stakeholders and users believe that the use of Go.Data is agreeable or satisfactory.	How do we, as an implementation team, foster support among stakeholders and all the users?
Appropriateness	Perceived compatibility with needs and practices of a setting or population; perceived utility in outbreak management and monitoring.	Why is Go.Data regarded as the relevant digital solution for outbreak management in our environment?
Adoption	Intention or action to attempt to use Go.Data.	How do we encourage clinicians in all five streams to use Go.Data? Why do some districts adapt quickly to changes while others do not?
Penetration	Reach or integration of Go.Data within the districts, facilities and community COVID-19 response processes.	How do we encourage the rapid response teams in the five streams to consistently use Go.Data daily and stop using paper?
Sustainability	The extent to which Go.Data is maintained or routinised within the setting over time.	How do we ensure that the Go.Data remains available after implementation when funding from partners has expired?

* The five different streams were 1) case identification, 2) case investigation, 3) contact tracing, 4) contact monitoring, and 5) case monitoring.

A basic checklist of elements considered in designing a plan for the qualitative implementation approach is presented in Table:13-4. The general areas considered in the context of the implementation of Go.Data were on feasibility, timelines, availability of resources, and speed of implementation, considering the moving target of COVID-19 hotspots, clusters, and chains of transmission. This process was like "*building a plane when it's in the air"*, a quote from Ms M Wolmarans during the Electronic Vaccination Data System (EVDS) implementation (Wolmarans et al., 2015:43). Feasibility is strongly linked to resources such as time, funding, scale-up, scope of the implementation, implementation team members, as well as the intended product. The implementation team considered all these crucial aspects.

Table 13-4: Key elements of qualitative implementation research (Adapted from Hamilton and Finley, 2019:4)

Key elements considered for the qualitative implementation approach	Aligning qualitative methods with Go.Data implementation research question
Identification of key stakeholders Who are the key stakeholders for implementing Go.Data? Whose support is necessary for the implementation to be successful?	Departmental leadership (provincial and district partners) Rapid response teams of all five streams Nurses and Technical Support team Implementation team, PTOC, WHO team, and the Right to Care team
Data collection instruments (e.g., CRFs) What do we need to know? How does the outbreak response framework guide Go.Data usage and complement the data collection approach?	Go.Data usage - thorough completion of individual CRFs Feasibility, acceptability, appropriateness, adoption, penetration, and sustainability
Timing of data collection (Go.Data usage and completion of the CRFs) When and how often will information be captured on Go.Data?	Capturing of information on Go.Data occurring during the execution of activities by all five streams.
Location of data collection – Usage of Go.Data Where will Go.Data be implemented? Where is it practical to engage the stakeholders and users?	Consultations, system demonstrations, and training will happen at the district level, with the district management team being targeted first. Thereafter, the training for the rapid response teams will take place at the designated places suggested by the district management. Online and/or telephonic training can also happen as a follow-up to clarify any possible system usage challenges.
Data collection team Who will collect and use the data? What level of training and experience will they require?	Rapid response teams comprising mainly clinicians and healthcare professionals in all five streams at each level of care will be using Go.Data. Computer usage skills and relevant clinical knowledge are paramount.
Recording of information on Go.Data Will conversations be recorded as they consult with the cases? By whom? What other forms of documentation will be maintained (e.g., notes and comments)?	Interviews captured on Go.Data immediately and comments to be captured in the comments section. No other forms of documentation will be required.
Data management How will data be stored to ensure compliance with ethics and organisational standards?	Rapid qualitative analysis using a focused, team-based approach.
Research ethics How will appropriate protections for participants be maintained at each stage of the response process?	Information about the cases will be kept confidential using the security features of the departmental systems and by considering WHO guidelines (2017).

Initially, a targeted approach for consultation (discussions with the technical support team, the provincial leadership, supporting partners, the PTOC and district managers) was applied. This was done centrally at the Health Head Office. These discussions were mainly based on the implementation team's experience working in Free State public health. No community members were consulted in this process, except the leadership from the Free State Red Cross Society, since there was insufficient time to consult with all the stakeholders. The rapid response teams and the entire district management teams were consulted on-site when the system was introduced, and the district-specific implementation plans were developed.

When the pandemic started, only doctors could do case investigations. However, due to the rapid increase in primary healthcare (PHC) cases, nurses were also utilised during the COVID-19 waves and contact tracing. It is well-known that digital technologies require unique computer skills to be developed, especially among clinicians and healthcare professionals, particularly older individuals. The FSDoH utilised data clerks to capture routine healthcare services from registers since most healthcare professionals and clinicians were not keen to use computers. Another aspect explored entailed the skills needed to successfully implement the project, focusing on the relationships depicted in Figure 13-6. A plan was developed to start with computer literacy training for healthcare professionals and clinicians in the rapid response teams. This was done before the Go.Data system was introduced to the users. Figure 13-6 illustrates the interdependence between disease management (innovation), skills, and digital technologies. The three vertices show the dyadic relationships between the three dynamics, usually studied in pairs. The systemic interaction between these three dynamics required the reorganisation of process flows of the different rapid response teams in facilities and communities, including the outbreak management processes at all levels of care. This, therefore, demanded skills in computer usage and adaptation to the use of Go.Data.

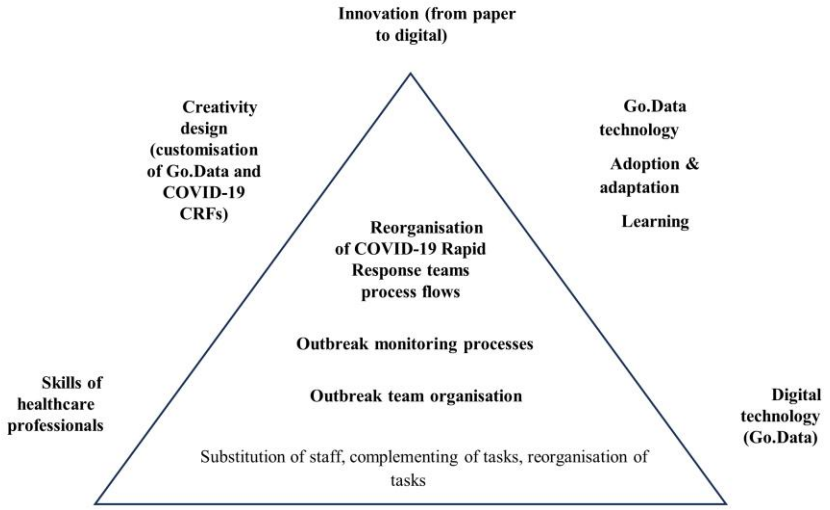

Figure 13-6: The triangular relationships of digital technology implementation (FSDoH, 2024)

13.5.4 Digital Transformation

Serious challenges with digital transformation include the lack of communication within the organisation and among the different sections and/or departments or insufficient transparency from the management to the employees about the changes about to occur (Westerman, 2018). It was thus important to ensure that the Communication Section participated in strengthening the communication part of Go.Data implementation.

After completing the initial consultation described above, the implementation team did an assessment and designed a plan for the implementation approach (Table 13-1). The implementation team, supported by the PTOC, obtained buy-in from all the relevant structures. This was followed by a one-week virtual training on Go.Data presented by the WHO Geneva Go.Data team to the Free State health professionals and information management teams. This was followed by three days of system configuration, including configuring location and reference data and adapting the case investigation form, contact follow-up form, and case monitoring form, including agreement on variables to be collected. Thereafter, the provincial case data and laboratory data were imported into Go.Data by the master trainers with guidance from WHO Geneva.

A PTOC was established to provide guidance and make technical decisions when deploying the Go.Data tool across the Free State province. Chaired by the HoD, the PTOC comprised managers and decision-makers in the following streams: case investigation, contact tracing, data management and information, communications technology, and the WHO team. To demonstrate the potential and capabilities of Go.Data usage in managing the outbreak, Xhariep district was identified as the pilot district because of its size and diverse setting (farming areas, rural areas, mining areas, and small towns). This setting would allow the implementation team to test the use of Go.Data in varied circumstances. Piloting of Go.Data usage in Xhariep took two weeks. Xhariep is the smallest district in the Free State, with only three subdistricts (Letsemeng, Kopanong and Mohakare) and a population of 131,901 with a total of 36,064 households.

The PTOC, implementation team and the Xhariep district management team jointly developed and approved the Go.Data district implementation plan considering the different settings in the district. The district Go.Data deployment process included: 1) training of healthcare professionals who were part of the rapid response teams on computer use; 2) training of the rapid response teams on using the Go.Data tool; 3) procuring ICT resources to support Go.Data use; 4) procuring additional HR resources for manual data back entry (from COVID-19 case paper files) into the Go.Data tool; and 5) enlisting partner support at the provincial and district levels to fast-track the deployment process.

A two-week pilot of testing the system and the CRFs was conducted in the three subdistricts of Xhariep district, which included five different streams: 1) case identification, 2) case investigation, 3) contact tracing, 4) contact monitoring, and 5) case monitoring of clinical professionals. It entailed accessing the system and capturing the information live after being trained in each of the subdistricts. The partners (e.g., WHO, Right to Care) supported this initiative by mobilising human and ICT-related resources. The PTOC and district management teams were trained on how to monitor activities using dashboards to identify COVID-19 hotspots and chains of transmission.

During the pilot phase, the district managers realised the effectiveness of using the system to monitor all the activities involved in COVID-19 CBS, including real-time data availability and continuous updating of the dashboards. As a decentralisation model, each of the five streams was

established in the three subdistricts. This helped break the chains of transmission of the disease in the community effectively and reduce hotspots. The system was, therefore, incrementally rolled out to the other four remaining districts to enable relevant and efficient ways of monitoring and managing the pandemic. The district managers were also trained to monitor the activities of the rapid response teams daily using the system-generated dashboards.

13.5.5 Piloting

The pilot phase was a success, noting an observed average increase in the case and contact follow-up rate and the case-to-contact ratio in the Xhariep district. The rate of hospitalisation and daily incidence of cases per 1,000 contacts (e.g., new cases on the previous day among known contacts, new cases on the previous day in known transmission chains.) were easily monitored.

Furthermore, there was a significant improvement in the quality of the case and contact data collected. The district reported that access to COVID-19 data in real-time facilitated a quicker response by the COVID-19 rapid response teams, even at the subdistrict level. The district manager acknowledged that the quality of data on COVID-19 cases and contacts had improved, and the availability of real-time quality data assisted in supporting the use of data to inform decision-making and strengthen the response across all levels of the district.

13.5.6 Go.Data Deployment in Other Districts

Following the successful pilot phase in Xhariep, Go.Data was deployed across the remaining four districts using the same implementation science approach. District-specific implementation plans were developed with the support of the district management teams.

13.5.7 Training

Training of the COVID-19 rapid response teams had three components, namely master trainers, face-to-face training and virtual training. In addition to the virtual provincial master trainers training provided by WHO Geneva, the district Go.Data champions were trained as master trainers in the districts, including compiling the daily situation analysis report by the provincial master trainers. This allowed for smooth implementation of the system and urgent data use. The rapid response teams from each of the respective subdistricts were trained, starting with computer usage training and then training on the Go.Data system. This training was both face-to-face and virtual. The district master trainers continuously provided face-to-face training where necessary, especially for new members of the rapid response teams. Provincial master trainers provided continuous virtual training as needed and face-to-face training on monitoring the dashboards and chains of transmission to the district management team.

All districts were required to replicate the provincial operational structures and pillars for the response. This approach was chosen because it standardised the response framework across all the

districts and would make the implementation of Go.Data easier. During Go.Data implementation, the districts further decentralised their responses to subdistrict levels. They also replicated similar structures and further decentralised to the PHC level in the subdistricts and communities. The established outbreak rapid response teams were based in the PHC clinics in the subdistricts for rapid response. They were all trained by both the district master trainers (face-to-face) and the provincial master trainers (both face-to-face and virtually).

The decentralisation of the rapid response teams to the lower levels yielded positive results in other countries. Similar to South Africa, research advocating for decentralisation of the management of COVID-19 generally has emanated from countries as diverse and as far afield as China (Lv et al., 2022), Spain (Erkoreka & Hernando-Pérez, 2022), Germany and Italy (Kuhn & Morlino, 2021), and Nigeria (Adejugbagbe et al., 2022). However, there seems to be no evidence of the efficiency and effectiveness of the decentralisation of COVID-19 CBS systems specifically. This is also the case in South Africa, where decentralisation of the healthcare system is legislated (NDoH, 2001).

13.5.8 Data Hosting and System Maintenance

A virtual training platform was created, and the officials were trained and mentored. The WHO and the Free State ICT Directorate developed a sustainability plan and process together. Officials were mentored on the Go.Data platform installation, configuration, support, maintenance and upgrading. This process included training various stakeholders on digital literacy and capturing and interpreting data.

The architecture used was defined in the context of the Government-Wide Enterprise Architecture (GWEA) Framework's Technology Reference Model (TRM) (Figure 13-7). The GWEA framework aims to set the minimum standard for using an enterprise architecture approach to

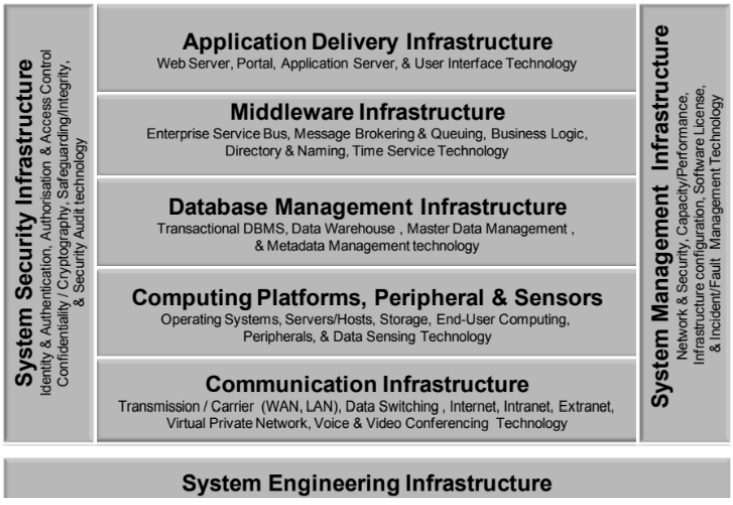

Figure 13-7: Technology Reference Model (TRM) (Government Information Technology Officer's Council of South Africa, 2010:12)

develop and construct ICT plans and blueprints (Government Information Technology Officer's Council of South Africa, 2010).

The GWEA TRM from the GWEA Framework Implementation Guide provides a structured approach to implementing enterprise architecture in government entities. The GWEA TRM was applied to install and utilise the Go.Data information system. Each TRM component was aligned with the system's requirements. This included mapping out the technology infrastructure, ensuring interoperability with existing systems, establishing security protocols, and setting up data management processes. The TRM's guidelines ensured a comprehensive and integrated approach to the Go.Data system, enhancing its effectiveness in managing COVID-19 data. Table 13-.5 provides a high-level overview of how each component of the GWEA TRM was applied to implementing the Go.Data system in the FSDoH, ensuring a structured and effective deployment.

Table 13-5: Technological Reference Model components and practical interventions (Adapted from Government Information Technology Officer's Council of South Africa, 2010)

TRM Component	Application in Go.Data Deployment	Practical Interventions
Technology Service Class & Definition	Identifying the specific technology services required by Go.Data, such as data storage, processing, and security services.	The Go.Data application server and database were initiated within a virtualised environment strategically situated within the confines of the FSDoH's Data Centre. This environment resides on the State Information Technology Agency (SITA) Government Network, safeguarded by robust firewalls and a multifaceted assemblage of information security strategies.
Interoperability Standards	Ensuring Go.Data aligns with existing interoperability standards within the Health Department for seamless data exchange.	Go.Data was meticulously designed with a foundational commitment to open standards. Open standards, characterised by their public accessibility, collaborative development processes, and emphasis on interoperability facilitate seamless data exchange among diverse products and services and are intended for broad adoption within the industry.
Technology Architecture Models	Outlining the architecture of Go.Data, including software, hardware, and network components.	The FSDoH deployed the most recent version of Go.Data (Version 3.2).
Technology Distribution Model	Planning the distribution of Go.Data components across various locations/environments within the Health Department.	The platform was hosted in a central location and could be accessed by all health facilities. Users could also connect to it on mobile devices such as cell phones or tablets through a safe internet connection.
Technology Gap Report	Identifying current technological gaps within the Health Department and how Go.Data addresses these.	The FSDoH did not have a system for regularly collecting COVID-19 patient health information when Go.Data was first introduced. Go.Data changed how the FSDoH was able to capture, track, and use patient data almost instantly.

TRM Component	Application in Go.Data Deployment	Practical Interventions
Consolidated Architecture Roadmap & Transition Architecture	Developing a comprehensive plan for transitioning from current systems to Go.Data, including incremental changes and timeline.	This was arguably the most difficult endeavour, given the limited time the Department had. This process involved the following: Scope analysis Conducting in-depth analysis across all units to fully understand current patient data and reporting workflows. Identifying all forms, registers and systems involved to get a complete picture of the transition needs. Gap assessment Mapping paper processes versus capability of the Go.Data system. Identifying processes and data integration gaps to define additional functionality/enhancements required upfront. Gradual rollout planning Prioritising rollout sequence, transitioning the highest volume sites first, at the readiest health facilities. Starting with the pilot district to trial forms/processes before expanding. This was conducted in the Xhariep district Change management Developing a communication strategy and training programmes targeting various user profiles. Creating online resources and tip sheets to facilitate self-service and peer learning. Setting up a dedicated helpdesk for frontline user outreach and support.

13.5.9 District Surveillance Monitoring Team

In order to enable smooth distribution of cases (sharing cases among case investigators) and constant monitoring of system usage, each district established a surveillance system monitoring team led by a Go.Data champion. This team made sure that the number of COVID-19 cases was distributed, investigated and monitored daily to ensure that all the streams were capturing the information on the system and that the data captured on the system was correct, complete and of good quality. The district epidemiologist, supported by the district Go.Data champion analysed the data using a standardised situation analysis report presented in the daily evening executive meetings.

13.5.10 Daily Receipt of COVID-19 Case Information on Go.Data

All laboratory-confirmed COVID-19 cases in South Africa were reported to the NICD, subsequently creating a case line list per province. A team of epidemiologists received the case line list daily, undertaking data cleaning and assigning subdistricts and towns to each case based on the laboratory where the cases underwent testing. The cleaned case line list was then sent to the provincial Go.Data system master trainers' team to import daily cases, ensuring that the district

Go.Data champions and subdistrict teams received information about new cases for investigation every morning.

13.6 Findings

The implementation of Go.Data enabled the Free State province to mount rapid responses to COVID-19 clusters and hotspots, effectively interrupting transmission chains. The district and subdistrict levels benefited significantly from the involvement of implementing partners and expertise from academic institutions and the diverse urban and rural healthcare facility landscape. Mangaung Metro, which recorded the highest cumulative COVID-19 cases in the Free State, strategically leveraged its proximity to provincial offices, the University of the Free State, and academic hospitals. Through Go.Data implementation, this district provided substantial normative guidance. This was crucial for establishing provincial COVID-19 response standards and optimising the surveillance system.

Deploying Rapid Response Teams at PHC clinics and utilising the case-based pandemic monitoring system (Go.Data) proved highly efficient, enhancing case investigation capacity and ensuring prompt investigations at local levels, thus reducing backlogs. Table 13-6 presents COVID-19 screening performance from March 2020 to July 2021. Thabo Mofutsanyane had the highest number of response teams (96), followed by Fezile Dabi (41). Additionally, Fezile Dabi boasted the largest teams, with up to 20 members, whereas some teams comprised as few as four members. During this period, a total of 12,421,802 individuals underwent COVID-19 screening, leading to 240,382 referrals for testing. Mangaung Metro exhibited the highest testing rate (2.45%), while Lejweleputswa recorded the lowest at 1.24%.

Table 13-6: Screening and testing performance by district, 16 March 2020 – 04 July 2021 (FSDoH, 2024)

District	Number of teams	Number of people in each team	Total number of people reporting for screening	Number of people referred for testing	Number of people tested	Testing rate (%)
Fezile Dabi	41	20	820	1,872 164	39,862	2.13
Lejweleputswa	38	4	152	3,242,572	40,081	1.24
Mangaung	35	10	350	2,795,236	71,087	2.54
Thabo Mofut-sanyana	96	12	1 152	3,687,958	69,531	1.89
Xhariep	38	4	152	823,872	19,821	2.41
Grand Total	267	60	2 626	12,421,802	240,382	1.94

A total of 27,989 close contacts have been traced since the onset of the pandemic. Initially, contact tracing was conducted on a limited scale due to concerns over privacy infringement, compounded by evolving national guidelines on contact tracing protocols. These concerns, including issues of privacy and fairness, have been extensively examined in various studies (Rowe, 2020; Vitak & Zimmer, 2020; Osmanlliu et al., 2021; Smith et al., 2020; Human Rights Watch, 2024). Table 13-

7 below provides an overview of contact tracing rates during the active implementation of GoData in the Free State province. Only Mangaung Metro fell below a 90% index case tracking rate, whereas contact tracing rates approached 100% across all districts. Fezile Dabi actively monitored contacts, while Lejweleputswa exhibited the highest testing referral rate for contacts, with Mangaung recording the lowest. Among referred contacts in Fezile Dabi, 46.7% tested positive, contrasting with a 9.8% positivity rate in Xhariep. The utilisation of Go.Data underscored the necessity for enhanced support for Rapid Response Teams, including robust data analysis from the PTOC, and highlighted the demand for additional technical expertise within districts.

Table 13-7: Rates of contact tracing by district, 16 March 2020 – 04 July 2021 (FSDoH, 2024)

District	Index case tracking rate (%)	Contact tracing rate (%)	% of contacts outstanding	Contact monitoring rate (%)	Contact referral rate (%)	Testing coverage among contacts of confirmed cases (%)	Positivity among contacts tested (%)
Fezile Dabi	96.5	99.96	0.0	15.7	7.1	100.0	46.7
Mangaung	88.4	99.8	0.3	0.1	6.4	100.0	14.7
Lejweleputswa	93.4	99.5	0.7	0.0	19.8	100.0	25.0
Thabo Mofutsanyana	98.0	99.8	0.3	0.2	16.7	100.0	13.7
Xhariep	94.1	100	0.0	0.0	7.9	100.0	9.8
Grand Total	**92.8**	**99.8**	**0.3**	**0.9**	**11.7**	**100.0**	**19.0**

The case fatality and recovery rates from March 2020 to July 2021 are detailed in Table 13-8 Thabo Mofutsanyana District reported the highest recovery rate at 90.62%, followed by Xhariep District at 89.10%. Across the Free State, there were a total of 116,698 confirmed cases, resulting in a case fatality rate of 4.3% and a recovery rate of 85.12%.

Table 13-8: Case fatality and recovery rates by district, 16 March 2020 to 04 July 2021 (FSDoH, 2024)

District	Total confirmed cases	Total deaths	Case fatality rate (%)	Total recoveries	Recovery Rate (%)
Fezile Dabi	16,545	740	4.5	14 375	86.89
Lejweleputswa	22,248	1048	4.7	19 177	86.20
Mangaung	48,236	1883	3.9	38 994	80.84
Thabo-Mofutsanyana	23,380	1207	5.2	21 188	90.62
Xhariep	6,283	194	3.1	5 598	89.10
Unknown	6	0			
Total	**116698**	**5072**	**4.3**	**99 332**	**85.12**

The use of Go.Data assisted the province in reporting on both community death (people dying at home) and postmortem death (death identified through postmortem). Mangaung and Thabo

Mofutsanyana had high numbers of deaths identified through postmortem. A high number of cases also died in the community of Thabo Mofutsanyana, as depicted in Figure 13-8.

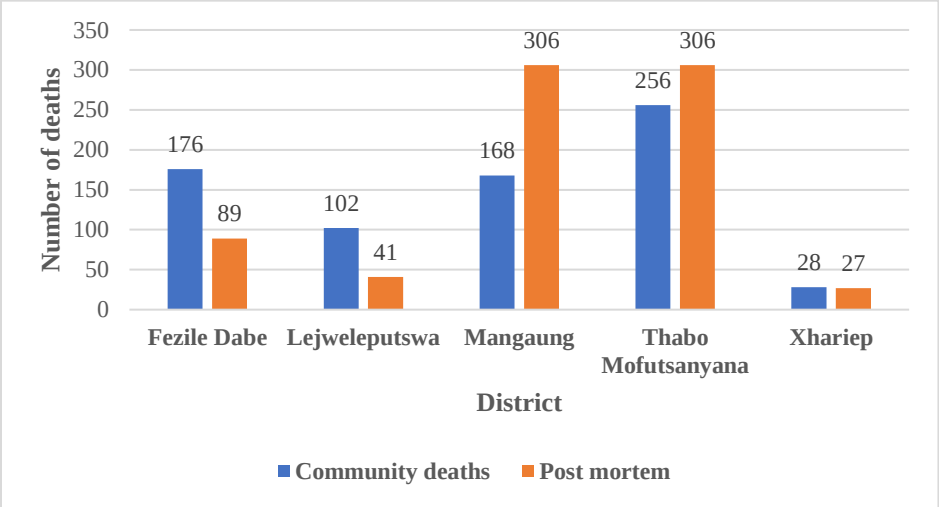

Figure 13-8: Out-of-hospital COVID-19 deaths by District, Free State, 16 March 2020 to 04 July 2021 (FSDoH, 2024)

The FSDoH consistently tracked daily COVID-19 cases, deaths, and recoveries by leveraging real-time data availability. Figure 13-9 below illustrates weekly trends in cases, deaths, and hospital admissions from the onset of COVID-19 on 16 March 2020 through 22 January 2022. By 31 March 2022, Go.Data reported a total of 207,829 cases, with 30,934 hospitalisations and 6,102 hospital deaths. The province encountered four waves of COVID-19, each marked by significant case numbers, hospital admissions, and fatalities. The first and second waves reached peak hospital admissions, the third was notable for its duration, and the fourth had the highest case count.

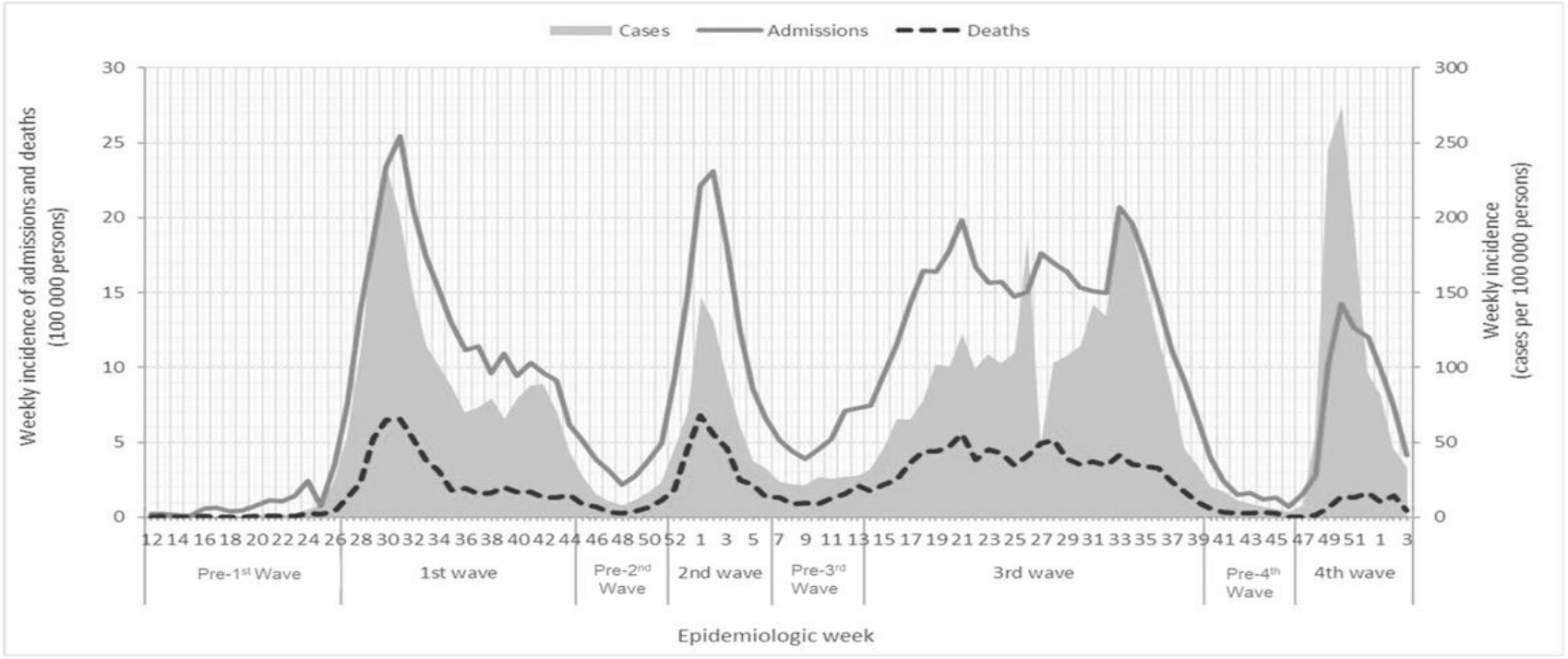

Figure 13-9: Epidemic Incidence: Weekly incidence of COVID-19 cases, admissions and hospital deaths, Free State, 16 March 2020 –– 22 January 2022 (FSDoH, 2024)

13.7 Benefits of Leveraging Go.Data for Pandemic Monitoring

Go.Data is designed to be user-friendly, making it accessible to a wide range of users and field workers involved in outbreak response. This accessibility was crucial during the fast-paced and high-pressure situations associated with outbreak response. The flexibility of Go.Data allowed for customisation to suit the specific needs of the FSDoH. This adaptability ensured that the software was tailored to meet the unique challenges and characteristics of the Free State province, as well as creating data profiles on district-specific outbreaks linked to the provincial outbreak.

Therefore, after adopting Digital Transformation, the FSDoH enjoyed multiple benefits with Go.Data implementation. These included increased efficiencies, innovation, competitiveness, productivity and new ways of interaction among the rapid response teams at different levels and the leadership of the Department (Matt et al., 2015; Westerman et al., 2014). Go.Data enabled easier coordination of COVID-19 district multisectoral response structures with clear command lines set up at the district level with daily real-time reporting systems from the subdistrict to the provincial levels. Coordination between the various levels was enhanced through daily online meetings to facilitate information sharing. Digitisation of COVID-19 data systems with the Go.Data tool enabled real-time quality data and assisted with building technological capacity among healthcare professionals (clinicians and nurses). This was evident during the implementation of EVDS since most of the vaccinators were already computer literate and only needed to be trained on the EVDS system.

Go.Data deployment also assisted with enabling timely risk communication and community engagement regarding CBS and points of entry, as well as highlighting the need for exit and entry requirement guidelines, including systematic screening, testing, quarantine, and isolation. This further facilitated the use of mobile laboratory units from the National Health Laboratory Service (NHLS) in the districts, thus facilitating the decentralisation of laboratory services, which supported mass screening and testing in the communities. This increased rapid case identification and management, improving infection prevention and control.

The availability of a web-based system enabled the establishment of several call centres at the district and subdistrict levels. Rapid response teams followed up cases telephonically as a monitoring mechanism, ensuring that patients recovered and ending the period of self-isolation where and when it was safe to do so. All the monitoring activities were captured in real-time on Go.Data. In addition, rapid monitoring of cases indirectly improved the logistical and operational support needed for the success of Go.Data implementation at all levels of care.

Reorganisation of services and streamlined processes and workflows for Go.Data implementation allowed the continuity of essential health services. This was confirmed by improved child immunisations during the pandemic (Heunis et al., 2023). Furthermore, among the nine provinces,

the Free State experienced the smallest decline in the number of people visiting health facilities (Pillay et al., 2021).

Go.Data facilitated accurate and efficient contact tracing, allowing rapid response teams to identify and monitor individuals who may have been exposed to COVID-19. It also streamlined the contact tracing process and enabled rapid and thorough contact tracing, essential for breaking the transmission chain and controlling the disease's spread. Furthermore, Go.Data provided a centralised platform that facilitated and streamlined the collection, management, and analysis of data related to cases, contacts, and other relevant information during the outbreak. This was crucial for understanding the dynamics of the outbreak, the spreading of the disease, and the implementation of effective and timely control measures. In addition, Go.Data is designed with data security considerations to ensure data confidentiality and integrity. This was critical when dealing with sensitive health information. Go.Data promoted data standardisation, ensuring that information was collected in a consistent and structured manner. This standardisation enhanced the quality and reliability of the data, making it easier to analyse and interpret the information.

13.8 Challenges Experienced

Initially, there was widespread resistance to implementing Go.Data even though the WHO donated the system to the FSDoH. Winter et al. (2010) highlighted the issue of resistance to change, stating that when organisations attempt to make a change, there is usually internal resistance from the employees, who sometimes refuse to learn new skills and accept new traits in their business environments. This is particularly the case with older employees or top management employees who influence the company hierarchy. The FSDoH was, however, fortunate because top management embraced the change.

Continuous demonstration and support from the PTOC regarding the capabilities of the Go.Data platform assisted in achieving buy-in. The districts had differing capacity levels and resource availability, making standardisation difficult. This was mitigated by developing district-specific implementation plans and the involvement of supporting partners to assist with the required resources. In addition, a rearrangement of roles and responsibilities to align with the need for critical skills of the rapid response teams using Go.Data was carried out.

Other challenges were the changing needs of the users, which resulted in constant changes in the CRFs to meet the needs of the rapid response teams. However, some of the fields could not be altered, and the FSDoH had to use proxies in such cases. While Go.Data played a crucial role in addressing the effects of the pandemic. The benefits from the system use were limited by structural factors, such as limits on connectivity (access, use and speed), especially in deep rural areas where capturing was done offline after the data was uploaded when the officials reached a place with sufficient network coverage. Hardware requirements and the need for change management at the peak of the pandemic were also challenging. However, they were mitigated by the support of the partners.

One important challenge was the use of non-editable Go.Data field names. The labels for addresses in Go.Data differed from those used in the primary data capturing forms, such as the Case Investigation Forms (CIFs) and contact listing forms. These forms utilised location names such as district and sub-districts, whereas Go.Data used location, city, postal code, and address. This discrepancy greatly impacted the accuracy and quality of the demographic data stored in the system. Using the information on the laboratory data forms assisted in improving the quality of the demographic data.

Initially, there were many incomplete CIFs for cases (i.e., confirmed, suspects, and probable) and contact listing forms for the contacts. Some of the primary data sources were partially filled, affecting the data quality in Go.Data. Constant monitoring of data completeness on the system and engaging the relevant officials helped improve data completeness and accuracy. Furthermore, Go.Data cannot identify duplicates, and some contacts were duplicated. This challenge was resolved by exporting the contacts to the R-Programme, where a script was run to clean the data daily before reporting.

The successful implementation of Go.Data depended on user training and adoption. Health professionals and fieldworkers must be adequately trained to use the tool effectively. Resistance to change or lack of familiarity with the software posed initial challenges. In addition, the accuracy and quality of the data collected in Go.Data depended on the diligence of data entry and the completeness of the information provided. Inaccurate or incomplete data can compromise the effectiveness of outbreak response and decision-making.

Implementing and maintaining Go.Data requires financial, material, and human resources. Although the supporting partners partially provided these, allocating the necessary resources for training, technical support, and ongoing maintenance remained challenging. Another challenge was the integration of Go.Data with existing health information systems as it was implemented in parallel with the other systems (e.g., DatCov) and databases. The integration was important for avoiding duplication of efforts and ensuring that the data flowed smoothly across different public health information management infrastructure components. As with any system handling sensitive health information, ensuring robust security measures and protecting privacy were critical. The FSDoH thus needed to address data security and privacy concerns to maintain public trust and compliance with regulations such as the Protection of Personal Information Act, 2013 (POPIA).

While allowing customisation as a strength of Go.Data, it was also a challenge, as this required continuous technical expertise and careful consideration to ensure that the software remained effective and user-friendly. The FSDoH also needed and received continuous support regarding ongoing software maintenance.

District-specific adaptations posed significant challenges, requiring a dedicated team to manage the complexities of change management, human resources, and necessary ICT infrastructure adjustments. Resources had to be strategically relocated to facilitate adaptation, necessitating

strong coordination. Consequently, each district appointed a Go.Data champion responsible for overseeing district-specific Go.Data activities. This role included managing the ongoing reallocation of Go.Data resources, tracking asset movements, ensuring timely entry of all COVID-19 cases into Go.Data, and supporting the effective utilisation of the system by pandemic management teams. The WHO and other partners provided essential training and change management support.

Local area managers' previous experience in implementing HPRS in clinics proved invaluable in integrating Go.Data into daily operations. Despite challenges, the sustainability of Go.Data is crucial for the Free State. The FSDoH plans to maintain and integrate Go.Data into broader health information systems, with provisions for upgrades and continuous improvement through training programmes. Internal capacity has been developed to leverage Go.Data effectively in future outbreaks.

13.9 Ethical Issues and Human Rights

The scale of the COVID-19 pandemic called for the need for an appropriate and rapid data collation, storage, and analysis system to strengthen evidence-based approaches to managing the pandemic as well as data-sharing methods (Brand et al., 2022). This needed to be achieved in line with the principles of transparency, fairness, and accountability. The urgent challenges of the pandemic included uncertainty due to changing information, compromised response capacity of local health systems and the increased role of cross-border collaboration (Brand et al., 2022; WHO, 2016). As this is ethically imperative, *rapid data sharing is critical during an unfolding health emergency* (Dye et al., 2016, p. 158). As highlighted by the WHO (2016), entities and individuals involved in pandemic management efforts should cooperate by sharing relevant and accurate data in a timely manner. The FSDoH considered the use of Go.Data to be an opportunity to provide timely and accurate data. A COVID-19-specific confidentiality agreement (Annexure A) was crafted to regulate data-sharing practices. It ensured robust protection and confidentiality of personal information, addressed ethical concerns such as managing incidental findings and resolved information ownership or control disputes. In addition, the COVID-19 data-sharing process was established through an internal instruction memo (Annexure B) that the HoD issued. The Go.Data platform incorporates comprehensive functionality to ensure confidentiality, addressing all legal and ethical considerations as outlined in its development (WHO, 2020). In addition, user access forms (Annexure C) and encrypted passwords were implemented to prevent unauthorised access to the Go.Data system (WHO, 2020).

As the WHO (2016, p. 7) indicated, time pressures and resource constraints may force action without the thorough deliberation, inclusiveness and transparency that a robust ethical decision-making process demands. Considering the rapid spread of COVID-19 and the absence of any proper pandemic monitoring system that provided timely data, a decision to implement Go.Data was taken irrespective of some resistance. It started as a pilot so that the capabilities of Go.Data

could be demonstrated, and buy-in from all the relevant stakeholders could be obtained. Buy-in was finally achieved by demonstrating what was cited by WHO (2017), namely that rapid collection and ethical sharing of data helps in identifying etiological factors, predicting the spread of COVID-19 and hotspots identification, symptomatic care and decision-making regarding preventive measures and guiding the deployment of limited resources (WHO, 2017).

In addition to concerns regarding the effectiveness of Go.Data in meeting public health goals, there were also concerns regarding the ethics, legality, safety, and sustainability of digital surveillance technology, given that most of its dependencies were provided by the supporting partners (Donelle et al., 2021; ECLAC, 2021). Concerns regarding the short-term and long-term potentials of Go.Data usage included undermining human rights as the system would be utilised by many HCWs, and personal information about the cases would be collected. Human rights advocates and knowledge leaders in digital technology insist that healthcare decision-makers balance technological innovation as a pandemic response with transparency, diligence, and attentiveness to issues of data standards, ethics, equity and human rights to effectively address the short-term and long-term implications on health and issues that determine health (WHO, 2017; Patel, 2020; Freeguard & Shepley, 2023). During global public health crises, data can be crucial for saving lives. However, its effective use hinges on clear guidelines grounded in law, ethics, and human rights for data management and governance, even during emergencies. Trust in institutions' responsible data use is essential (WHO, 2017; Donelle et al., 2021; The Royal Society, 2021). This may mitigate the growing risk to privacy and personal data security.

Ethical considerations in implementing Go.Data were addressed through a systematic ethical analysis. This process involved identifying pertinent principles, applying them to specific situations, and making decisions when competing principles could not all be fully satisfied following WHO's ethics guidelines (2016). These guidelines emphasise the following ethical principles that can be applied to infectious disease outbreaks: justice, beneficence, utility, respect for persons, confidentiality, reciprocity, patient autonomy and solidarity (WHO, 2016; Janarthanan et al., 2024).

- Justice*:* This can be considered as encompassing two different concepts. The first is equity, which refers to fairness in distributing resources, opportunities, and outcomes. Key equity elements include treating all cases alike, avoiding discrimination and exploitation, and being sensitive to persons especially vulnerable to harm or injustice. Procedural justice, as the second component of justice, entails a fair process for crucial decision-making. The implementation of Go.Data facilitated timely accounting and investigation of all cases reported through the NICD, aligning with epidemic management procedures conducted within the Go.Data system. While systematic consultations with community members were not universally feasible, efforts were made in certain localities to engage community representatives.
- Beneficence*:* Beneficence involves actions aimed at benefiting others, such as alleviating

pain and suffering. In public health, this principal underscores society's responsibility to address the fundamental needs of individuals and communities, including humanitarian essentials such as food, shelter, health, and safety. The decision to implement Go.Data was driven by the aim of safeguarding public health through swift interruption of COVID-19 transmission chains and identification of hotspots.

- Utility: The principle of utility posits that actions are ethical when they enhance the well-being of individuals or communities. Maximising utility involves weighing potential benefits against risks of disease transmission and ensuring efficiency, striving to achieve maximum benefits at minimal costs. Go.Data was utilised to mitigate the risk of disease transmission and swiftly identify hotspots for prompt investigation.
- Respect for persons*:* The term respect for persons refers to treating individuals in ways fitting to and informed by recognising our common humanity, dignity, and inherent rights. The central aspect of respect for persons is respect for autonomy, which requires letting individuals make their own choices based on their values and preferences (Nichol & Antierens, 2021). This is normally achieved using informed consent. During COVID-19 case investigations or contact tracing, clients who chose not to disclose information were not pressured; they voluntarily provided the necessary information. Ferretti and Vayena (2022) suggest that digital contact tracing is important for public interest and security. Additionally, respect for persons was upheld by implementing a privacy and confidentiality document (*Annexure A*). Officials and any supporting partners handling data from the system were required to sign this document, ensuring adherence to privacy and confidentiality protocols. Finally, respect for persons requires transparency and truth-telling in the context of carrying out public health activities. Although there was no meaningful engagement with the general communities on data-sharing during case investigations and contact tracing, the clients were informed that the information they provided was monitored through the Go.Data system.
- Confidentiality*:* WHO (2016) defined informed consent as a process in which a competent individual authorises a course of action based on sufficient relevant information without coercion or undue inducement. A scoping review conducted by Maxwell et al. (2023) found that most countries have legal frameworks for sharing participant-level data in the public health response to an emergency, such as the COVID-19 pandemic, irrespective of consent. Although informed consent is one way to operationalise the concept of respect for persons, no written informed consent was provided when monitoring the COVID-19 pandemic through the Go.Data system. It was, however, implied since the provision of investigation information was voluntary. Furthermore, informed consent upholds respect for individual autonomy, minimises coercion and undue influence, and protects privacy.
- Reciprocity*:* This was accomplished by ensuring the fair allocation of benefits and responsibilities in epidemic response efforts among HCWs across the province. The rapid response team prioritised having teams from specific districts investigate and monitor

clients within their own districts. Furthermore, a call centre was established to aid districts with the highest daily case numbers, enabling rapid intervention to effectively disrupt transmission chains and identify hotspots.

- Solidarity*:* The implementation of Go.Data enabled collective investigation and contact tracing across multiple districts, significantly aiding in breaking the transmission chains of COVID-19 within the community. This initiative exemplified a commitment to the principle of solidarity.

In summary, despite the urgency to control the spread of COVID-19, which limited opportunities to carefully consider both intended (disease containment) and unintended (such as potential ethical and human rights violations) consequences, the implementation team developed a Standard Operating Procedure for surveillance data usage. This procedure was crafted following WHO's (2017) *Guidelines on Ethical Issues in Public Health Surveillance*. Furthermore, the HoD issued instructions on accessing pandemic data per the Department's Data Governance Framework. The Information Management and Research Directorate of the FSDoH provided regulatory oversight. Following the WHO's declaration of the end of the pandemic, the Department discontinued the use of Go.Data and ceased all related activities in compliance with WHO sunset clauses.

13.10 Value

During the COVID-19 pandemic, the Free State province adopted Go.Data, customising it to align with South African pandemic management policies and guidelines. The Free State was the first province to integrate these policies seamlessly into the Go.Data system, presenting a unique approach to pandemic management in South Africa later adopted by other provinces. The implementation of Go.Data was collected using Agile project management principles. According to Hoda et al. (2008), Agile methodologies involve iterative and incremental development that adapts dynamically to changing requirements, enhancing risk management. Stare (2013) further concluded that Agile project management represents an innovative 21st-century approach, allowing for continuous product evolution through iterative cycles and the incorporation of new requirements, leading to intermediate deliverables that can be immediately utilised (Goodison et al., 2019).

The successful implementation of the Go.Data system for COVID-19 data management depended on a thorough consideration of both its technical capabilities and the social dynamics within the healthcare environment of the Free State. The concept of *socio-technical fit* underscored the intricate relationship between Go.Data's technological functionalities and the complex operational realities of hospitals, clinics, and public health offices grappling with the pandemic. Ignoring this interaction posed risks of unintended consequences that could undermine the effectiveness of Go.Data. Therefore, adopting a holistic approach that comprehensively addressed the socio-technical landscape was essential to achieving a seamless transition and maximising the potential benefits of Go.Data.

While the current research has focused on factors influencing the implementation of Go.Data, a significant gap remains in understanding its impact on patients and communities affected by COVID-19. The absence of studies evaluating Go.Data's benefits or drawbacks from the perspective of those it serves is troubling. Patients and communities, as the primary beneficiaries, should have been central to these assessments. Failing to prioritise their experiences perpetuates a top-down approach and risks missing opportunities for Go.Data to better meet the needs of those most affected by the pandemic. Future public health technology initiatives must prioritise patient-centred and community-centred evaluations to ensure effective and responsive implementation.

In the Free State province, developing business processes within existing structures and establishing rapid response teams at lower levels of care significantly enhanced pandemic management efficiency. Adopting Go.Data facilitated a seamless and effective CBS process, improving data quality and timely reporting. Standardising rapid response teams posed challenges, but structures were successfully aligned at the district level based on available expertise and capacity. District-specific training plans ensured a gradual implementation of Go.Data, fostering user adoption and acceptance by district management teams. The strategy of involving clinicians and professional nurses directly in data capturing proved successful, simplifying the implementation of the EVDS as most vaccinators were already computer literate.

The National Digital Health Strategy emphasises key principles such as interoperability, data security, scalability, and user-centric design (NDoH, 2019). Go.Data followed these principles when deployed in the Free State province, where it integrated with existing health systems, adapted to local outbreak management needs, and provided real-time data access. This improved the technological skills of healthcare professionals and made outbreak management more efficient, which matches the Strategy’s goal of using digital technologies for better health outcomes.

However, the implementation also faced some challenges that did not match the Strategy. For example, some older healthcare professionals initially resisted change, highlighting the need for better change management strategies for different user groups, which was not entirely done during the initial rollout. Also, connectivity problems in rural areas made Go.Data difficult to use, which shows a gap in the digital infrastructure that the Strategy wants to improve. The need for ongoing technical support and customisation of the system also highlighted problems in scalability and standardisation, as different districts needed different adaptations and support.

In order to overcome these challenges, the practical problems encountered during Go.Data’s implementation should be recognised and used to improve future digital health initiatives. By following the Strategy’s ideals more closely and solving identified barriers, deploying digital health solutions (e.g., Go.Data) can be more effective and lasting. Explaining these aspects in detail would give a more complete understanding of Go.Data’s impact and offer useful lessons for policymakers and health professionals in making digital health strategies more applicable and successful.

13.11 Conclusion

The FSDoH reaped significant benefits from deploying the Go.Data digital platform for COVID-19 Case-Based Surveillance (CBS), thereby greatly enhancing pandemic management. The efficiency of COVID-19 rapid response teams was notably enhanced, enabling officials to operate remotely and respond more swiftly to break transmission chains. A key advantage was the top management's ability to monitor response activities at the grassroots level. Go.Data seamlessly integrated into the Department's information ecosystem, supplanting the paper-based system and establishing a more sustainable digital CBS framework.

Decentralising the Go.Data platform as a Case-Based Surveillance (CBS) tool for the COVID-19 response in the Free State ensured a more sustainable approach and promoted ownership of the response throughout the healthcare structure. This approach effectively utilised resources despite limitations, streamlined processes, and enhanced data quality, timeliness, and availability. District managers reported accurate information from Go.Data during daily meetings, facilitating easier management of activities. Provincial managers could monitor these activities effectively and identify areas requiring additional support.

Go.Data's capability to identify transmission chains and disease clusters significantly strengthened COVID-19 containment efforts in the Free State. Its deployment bolstered the province's preparedness to swiftly and effectively respond to future outbreaks, a recognition highlighted by the WHO (2022) in acknowledging how decentralisation enhanced COVID-19 control efforts in the Free State. Ultimately, digitisation and decentralisation underscored the pivotal role of coordination in pandemic response, contributing to successfully mitigating the pandemic's impact across all levels of healthcare provision.

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Annexure A: COVID-19-specific Confidentiality Agreement

CONFIDENTIALITY AGREEMENT
Between

_____

Herein referred as Head of FSDoH

And

_____

Herein referred as health information supporting partner

PATIENT INFORMATION (DATA) CONFIDENTIALITY

COVID-19 Support official should:

Recognise the right of patients and that health information support official will not disclose any personal and confidential patient information (data) they acquire in the course of their duties, unless the patient agrees to such disclosure, or unless health information support official has a good and overriding reason for doing so (for example, if disclosure is not made, there is the likelihood of serious harm to an identifiable third party, or there is a public health emergency, or any overriding and ethically justified legal requirement).

Personal confidential data items should not be included at any given point by the health information official or support partner unless it is essential for the specified purpose or as directed by the Head of Health (proof directive to be provided)

Patient information (data) should NOT be shared with any official or 3rd party outside the Free State Department of Health employment unless a DATA USER AGREEMENT FORM is completed and signed by both parties (This form is available in the information management directorate at the Provincial office)

NOTE: Breach of patient information (data) confidentiality without sound reason and without the knowledge of the patient is a **DISMISSIBLE OFFENCE**.

CORE VALUES FOR HEALTH INFORMATION SUPPORT OFFICIAL

Integrity: The health information support partners should incorporate these core ethical values and standards as the foundation for his/her character and practice as a responsible health information support officials.

Truthfulness: Health information support partner should regard the truth and truthfulness as the basis of trust in his/her day today activities.

Confidentiality: Health information support partner should treat personal or private information as confidential as he/she works with patient data - unless overriding reasons confer a moral or legal right to disclosure.

I _____ (Name & Surname), have understood and agree to the confidentiality agreement accompanying my appointment as a

_____ (Position & Title) in the Free State Department of Health.

Health information support partner _____
(Name & Surname)
Signature_____
Date _____

Supervisor _____ (Name & Surname)
Signature_____
Date _____

A copy of this form to be send back to Provincial information management through the office.

Approved by

_____ Date _____
DDG Corporate office Services
Free State Department of Health

Annexure B: Internal Instruction Memo

health

Department of Health
FREE STATE PROVINCE

Internal Memo

Date:	08 February 2022	File No:	
To:	DISTRICT DIRECTORS & HOSPITAL CEOS PROGRAM DIRECTORS PROVINCIAL SURVILLAMCE TEAM PROVINCIAL INFORMATION MANAGEMENT TEAM & PROVINCIAL ICT TEAM ALL HEADS OF UNITS ALL OFFICIALS HANDLING DATA & ALL SUPPORTING PARTNERS	From:	Mr MNG Mahlatsi Head: Health

COVID -19, VACINATION AND HEALTH CARE SERVICES DATA REQUEST

Dear Management

It has come to my attention that COVID-19 data of the Free State is being shared with third party without following proper departmental processes. I would therefore like to outline the procedure to be followed. All COVID -19, vaccination and the health care services data of the Free State department of health resides with the information management Directorate, therefore any data requests should be directed to the HOD via the office of the Director information management of the Free State department of health. Please note that any request for data should be accompanied by clear and specific rational.

- No official of the Free State Department of health including supporting partners, shall handle and share the data (COVID -19, Vaccination and health care services) without recommendation from the director information management.
- All the officials handling data in the Free State department of health including supporting partners must sign the data agreement form and a copy of the signed form to be submitted to the director information management Directorate.

The contents of this circular must be implemented with immediate effect.

Kind Regards,

MNG Mahlatsi
Head of Department: Health
Date:

Head: Health
PO Box 227 Bloemfontein 9300
4th Floor Executive Suite Bophelo House cnr Maitland and Harvey Road Bloemfontein
Tel: (051) 4081107/8 Fax (051) 4081055 e-mail hodpa@fshealth.gov.za
www.fs.gov.za

Annexure C: Go.Data User Access Form

New users that require access to the Go.Data, OR Existing Users that want to change/edit their current permissions, will have to complete this registration form. Kindly complete the required user information and upload the form onto the Go.Data system to which you are requesting access. ONLY after signoff and approval, will the user be created or edited. Users should refer to the list of user roles and datasets that is available on the General dashboard in the database.

Go.Data User Information:

For existing users, only specify/tick the changes/additional e.g., Orgunit, user role, data set. If Termination box is ticked, provide the termination date.	☐ **New User** ☐ **Existing User** ☐ Change Password ☐ Change/Addition of Data Set Access ☐ Change of Organisational Units Access ☐ Change/addition of user role Termination Date:
First name (in full)*	
Surname (in full)*	
Email Address	
Position (e.g., Data Capturer, Information Officer etc)*	
Place of employment*	
ID Number*	
PERSAL/Employee Number*	
Cell phone Number (e.g., 082 123 1234)*	
Please specify the **District** for Capturing & Reporting (the user will have access to this org unit and all its children) *	

Note: The list of datasets or programmes will differ between different Go.Data instances. Thus, this form will be used per instance and uploaded for access on the Registration Dashboard of each instance
***The list of data sets or use roles is also depended on the database that you are requesting access to, please check the role you are requesting access for: Data Capturer ☐ Data User ☐ Create User ☐ Report Viewer ☐

Signing off Section	
Date	User's Signature
Manager / Supervisor Name	Manager / Supervisor Surname
Manager's Position	Manager's Contact No
Date	Manager's Signature

Chapter 14: The Importance of Skills-Based Set in Solving Support Queries and Providing Input in Improving the Health Patient Registration System

Thulare, T.,[1] Maremi, K.,[1] Nthatheni, R.,[1] Mthethwa, S.[1] and Mahwai, N.[1]

[1]Next Generations Enterprises and Institutions Cluster, Council for Scientific and Industrial Research (CSIR)

Purpose: *HPRS is based on a Linux/Ubuntu platform and individuals are not familiar with the environment. Training in the language and environment is required to understand how the system functions, how to improve the system, and how to solve client-based queries. Therefore, the chapter aims to improve the maintenance and support by enhancing the skills-base set to minimise the daily queries. Getting the skills will ensure that the different tier levels are adequately equipped to troubleshoot the issues encountered. It will also allow the various tiers to identify innovative ways to improve the system functionality and reduce the impact of system downtime. There is a lack of skills at the different tier levels required to assist in the effective operations of the support and maintenance environment. This research is being conducted to obtain insights regarding the importance of a skills-based set-in solving support queries. This research aims to provide recommendations to improve the performance of the Support and Maintenance ServiceDesk team in the HPRS environment.*

Study design/methodology/approach: *This study took an exploratory qualitative approach and tried to explain how and why a certain phenomenon or behaviour behaves in a certain way in a certain situation. Inductive reasoning was used, which involves moving from the specific to the more general and from cause to effect by moving from effect to cause. Additionally, an online open-ended questionnaire was employed. The Lime Survey software was used to facilitate the online survey. Purposive, convenience, and snowballing sampling techniques were used for this investigation.*

Findings: *The findings show that the support and maintenance team must have analytical, communication, time management, interpersonal, basic developer, adaptability, problem-solving, stress management, people skills, Ubuntu/Linux server basics, and technological skills-based sets. These skills-based sets - will solve support queries effectively and efficiently and ensure the continuous improvement of HPRS.*

Originality/value: *The significance of this study lies in its contribution to the existing body of knowledge. With the continuous evolution of technology and the imperative for organisations to ensure that their workforce strategy is in sync with dynamic business priorities, adopting a skills-based approach has emerged as a highly effective organisational*

strategy. This approach optimises operational efficiency while enabling organisations to stay competitive in an ever-changing business landscape.

Keywords: *Skills-based sets, Support Queries, Service Desk, HPRS*

14.1 Introduction and Background

The Health Patient Registration System (HPRS) is a system that was commissioned by the National Department of Health (NDoH, 2019a). The department partnered with the Council for Scientific and Industrial Research (CSIR) to develop and implement the system in healthcare facilities (NDoH, 2019a). The main aim was to capture and store demographic information of people who access healthcare facilities. This would assist the department in planning budgets and providing healthcare to people who need health services at healthcare facilities (NDoH, 2020). HPRS is a supporting building block of the National Health Insurance (NHI) that would help when NHI comes into effect (NDoH, 2019b). Based on this joint vision, the HPRS is the authoritative source of demographic information for the National Department of Health (NDoH, 2022). The HPRS has been deployed to more than 3000 public healthcare facilities around the country and further enhancement of the system is still being undertaken by the CSIR (NDoH, 2022).

Information Communication and Technology (ICT) support is one of the key external factors, which is performed by providing support when requested by end users on hardware and software products. The support can be provided via several channels; the most popular ones include the Internet, phone, fax, help desk, machine-readable knowledge base method, and remote login (Alshammari, Ali, and Rosli, 2016). ICT system engineers, subject matter, and experts find it more and more challenging to support and maintain their systems as these systems grow incredibly huge, complex, and integrated (Ogata, Takeuchi, Fukuda, Yamada, Ochi, Inoue, and Ota, 2020). When an issue arises with an ICT system, troubleshooting steps must be followed. This requires the system engineer and subject matter experts to identify the root cause of the issue and fix or replace it (Ogata et al., 2020). ICT systems differ, as do the challenges faced and the best ways to solve them. It remains crucial to secure adequately competent system engineers, subject matter, and experts to allow stable operations and support and maintenance of ICT systems (Ogata et al., 2020). Installed technology requires ongoing maintenance and support to function correctly. Current trends in technology system support include establishing a formal technology support structure and using a service desk to track support queries and responses.

The service desk is responsible for coordinating events and service requests as well as communicating with users. The service desk provides a clear path for users to report issues, queries, and requests and to have them acknowledged, classified, owned, and addressed (ITIL,019). Different levels of support are provided within the service desk. Level 1 is referred to as the front line of the service desk, and level 2 is the advanced tier of support with more experienced

and knowledgeable technicians with the skills to provide solutions for escalated problems from level 1. Level 3 consists of subject matter experts focused on specific technologies and applications (Hall, 2016). Problems are escalated from level 1 to 3 based on the technical severity of the issue and include internal service desk support. Therefore, by coordinating IT requests and issues through a well-established team of experts, the service desk can manage them efficiently, providing a better user experience by resolving problems quickly and allowing regular feedback to improve HPRS support. To ensure the continuous enhancement of the HPRS support, it is recommended that adequate training is provided to the personnel who operate and manage the system to support both the front-end and back-end functions of the Information System (IS). The HPRS has a dedicated team that manages system operations, maintenance, and support.

14.2 NHI-IS Service Centre Process

The National Health Insurance Information Systems (NHI-IS) Service Centre provides the services necessary to ensure a well-functioning IS, including the necessary people, policies, procedures, equipment, software, networks, and datasets (Steenkamp et al., 2017). A thorough understanding of the responsibilities of the personnel engaged in service operation is required to ensure that HPRS is effectively operated. The establishment of the service centre, which handles incident control and user communications, operates in such a way that users are aware of progress on resolving incidents. As one of the other IS that utilises the NHI-IS Service Centre, HPRS agents can escalate tickets from their primary department to the HPRS CSIR 3rd Line Support, where they can be managed according to the agreed Service Operation Procedures (SOP) between NDoH and CSIR. Figure 14-1 outlines how the NHI-IS Service Centre escalates tickets to HPRS CSIR 3rd-line support.

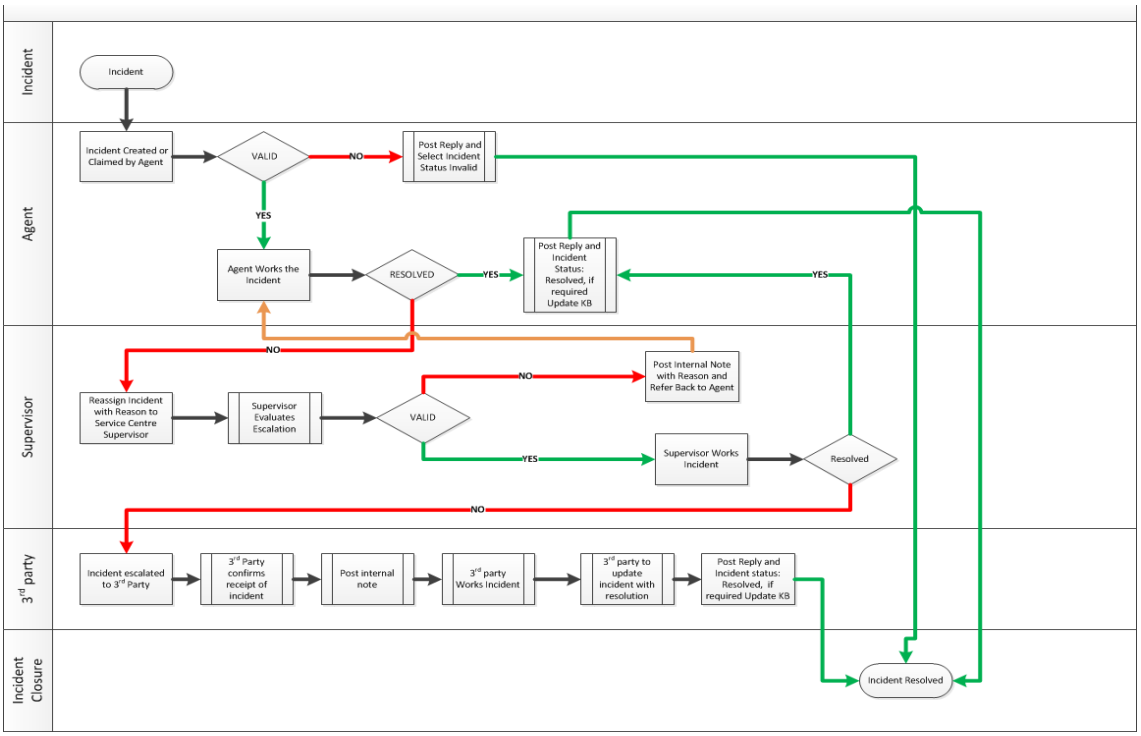

Figure 14-1: NDoH and CSIR Ticket Escalation Process as adapted from (Steenkamp, Fabe, Pretorius, and Aucamp, 2017)

14.3 Alignment with South African Digital Health Strategy

As defined by the World Health Organisation (WHO), digital health is the use of Information and Communication Technologies (ICTs) to improve the flow and use of information to deliver and manage healthcare services. With the increasing demand for healthcare services, changing how healthcare systems are organised and managed is necessary, including incorporating digital solutions to support timely and accurate decision-making (WHO, 2021). The South African Digital Health Strategy was developed on five main strategic principles (NDoH, 2019a).

- Person-centred.
- Expanded access to service.
- Innovation for sustainable impact.
- Digital health workforce for economic development.
- Whole-of-government approach.

Having set forth a vision of *"better health for all South Africans enabled by digital health,"* the strategy aims to advance the National Department of Health's vision of *"[a] long and healthy life for all South Africans*", while also advancing digital health as a significant driver of health system transformation. It is centred on the needs of individuals seeking healthcare, those who can be

assisted in maintaining a healthy lifestyle, health workers who provide a wide range of health services, as well as managers who need to make critical decisions to improve the effectiveness of the health systems (NDoH, 2019a:p18). In its problem statement, inadequate human resources is identified as one of the primary challenges confronting the South African healthcare system. To this end, one of the strategy's components is a Digital health workforce driving economic development (NDoH, 2019a). The strategy interventions aim to strengthen digital health technical capacity and create a skilled workforce for digital technology support and implementation. As an initial prerequisite towards developing a patient Electronic Health Record (EHR), the department launched the HPRS project. According to the Presidential Health Summit Compact, Pillar 9 necessitates capacity building and skill transfer in digital health. That is to identify Health Information System training requirements across the health sector as part of the baseline assessment (Narwal, 2019). Achieng (2021), states that providing proper training and support programs for healthcare practitioners to use health information systems in their professional activities can potentially improve health outcomes directly or indirectly.

The deployment of HPRS in healthcare facilities was complemented by the necessary training procedures so that users could operate the system efficiently. Healthcare facilities continue to use HPRS to register new patients, schedule appointments, and perform other administrative functions such as facility visits. The former Minister of Health, Aaron Motsoaledi, emphasised that achieving successful digital health demands the acquisition of new skills and innovative approaches by the current human resources (NDoH, 2019a). HPRS is dedicated to advancing the digitisation of healthcare. To ensure efficient digitisation, it is necessary to have a proficient personnel and customer base in using installed health technology and systems (Narwal, 2019). Training is essential to develop new and existing human resources for digital health, preparing them to be skilled workers who can support the digital health system. For this reason, this research study advocates the importance of skills-based training and development for resolving support queries efficiently and effectively. This will ensure that healthcare workers can use HPRS with the least disruption.

14.4 Methodology

The research study followed an exploratory qualitative approach and sought to explain *how* and *why* a particular phenomenon or behaviour operates as it does in a specific context (Maree, 2019). According to Du Plooy-Cilliers, Davis, and Bezuidenhout (2014), this type of study usually refers to the study of a new area of research. The research study follows a phenomenological approach to determine the meaning of an experience while it is being experienced and to provide a comprehensive description of that experience (Maree, 2019). This research explores the importance of a skills-based set-in solving support queries and providing input in improving the Health Patient Registration System. The methodology will be phenomenology, which focuses less on the researcher's descriptions but more on the description of the individual's experience of the phenomena (Maree, 2019). Using inductive reasoning, the theoretical framework will be derived

from the collected data, one moves from the specific to the more general, and the research context is also considered as one move from effect to cause (Yin, 2018). This was a cross-sectional study, as data was analysed at a single point in time, which is less time-consuming and less expensive (Yin, 2018).

The research study applied literature reviews to better understand the phenomenon by examining other authors' previous scientific evidence (Yin, 2018). Various sources were employed, including books, conference papers, theses, dissertations, and the Internet. The databases ScienceDirect, IEEE Xplore, Scopus, ProQuest, Web of Science, and the search engine Google were used to examine publications published between 2014 and 2024. The research study examined articles published between 2014 and 2024. The search terms included *Skills-based practices*, *service desk*, *Training, Support Tickets*, and *Importance of Support and Maintenance*. Several research themes were identified and organised while reviewing the papers, including literature related to training and its impact on the support and maintenance environment, particularly on the process of handling support tickets. Following the literature analysis, the terms that appeared most frequently in the literature can be seen in Figure 14-2.

Figure 14-2: Word Cloud Based on Literature Review (WordCloud, 2024)

Additionally, an online open-ended questionnaire was employed since, as Yin (2018) notes, open-ended questions are often used in qualitative research. The Lime Survey software was used to facilitate the online survey, and ten (10) participants completed the survey successfully from February 19-23, 2024. Purposive, convenience, and snowballing sampling techniques were used for this investigation. It is known as non-probability sampling, and in exploratory qualitative research, it is frequently employed to achieve exploratory objectives. In the population, selection is unknown or uniform, and samples are used to examine real-world phenomena rather than make statistical inferences about the larger population. Participants were selected based on their availability and, more specifically, their ICT-related knowledge. Participants included individuals with prior experience working in a maintenance and support helpdesk environment. The profiles of the participants are provided in Table 14-1 below.

Table 14-1: Profiles of the participants

Position	Years of experience	Number of participants
3rd Line Technical Support Helpdesk	3-4	2
Support and Maintenance Supervisor	6	1
Information Systems Practitioner	4	2
Information Technology – Network Technical Support	12	1
Operations, Support and Maintenance	2	1
Technical Support	1-4	3

14.5 Literature Review

This section presents the literature review findings. It defines what an ICT service desk is and how support requests are handled throughout its lifecycle. The section also examines skill-based sets, their value, and how to improve them.

14.5.1 ICT Service Desk Support

The organisation employs various methods of ensuring customer satisfaction. One way involves investing in technical support, a type of customer service that deals with customers' technological issues (de Castro Silva, de Oliveira, and Gonçalves, 2016). Technical support can be divided into three categories: Level 1, which deals with basic IT support for simple customer requests; Level 2, which handles more complex issues; and Level 3, which involves bringing in subject matter experts to address the most challenging customer requirements (Kirjavainen, 2016). The benefits of dividing your technical support into tiers are as follows (Firmansyah and Subriadi, 2022):

- Enhancing the client experience by offering efficient and dependable customer service.
- Creating distinct roles and duties for effective service delivery and strategic management.
- Fast completion of simple tasks.
- Increasing worker satisfaction by promoting technicians to various support positions.

14.5.2 Improving feedback systems by answering questions from users

- ***Level 1 Support***

Level 1 support is provided by IT personnel who are less experienced and have a limited understanding of technical issues. Their primary responsibilities are to provide product information, gather customer requests and data, answer customer phone calls, reply to user emails, conduct basic troubleshooting to determine the level of support required, create tickets for Level 2

support, and resolve common issues like menu navigation, username and password problems, and hardware and software version problems (Firmansyah and Subriadi, 2022). The first level of support for HPRS is managed by field technicians commissioned by NDoH and IT District technicians. These technicians are the clients' primary point of contact and are responsible for receiving and processing client requests. If the issue cannot be resolved at this level, the field technicians will escalate it to Level 2 support by opening a ticket.

- ***Level 2 Support***

Level 1 inquiries are handled by Level 2 personnel. Level 2 involves detailed analysis and troubleshooting to determine the user's issue, the amount of support provided by Level 1, and how long the customer has been working with the agent. Level 2 personnel review the support query submitted by the Level 1 agent, investigate the problem more thoroughly, and consult with the user before recommending a solution (Kamal, Tusher, Ahmad, Farin, and Mansoor, 2019). While they may know programming or system usage, they are usually not engineers or architects who have worked directly with the hardware or software in question (Kirjavainen, 2016). The request is escalated to Level 3 support if a solution is not found. The second level of support is NDoH personnel and consultants. From time to time, the agents engage with the users directly and they contact the IT District technicians to do the initial analysis of the user's query. They do an in-depth analysis of the queries as they have access to some of the system functionality. The agent will try to resolve the problem remotely using TeamViewer or Windows remote desktop if the facility is offline, the request can be resolved over the phone. Usually, queries escalated at their level are resolved and only transferred to Level 3 when they encounter system-related and virtual machine (VM) support queries.

- ***Level 3 Support***

Level 3 support requires Subject Matter Experts (SMEs) who are experts in their respective fields. These specialists may include architects, engineers, manufacturers and other experienced professionals with access to the latest business and system information (Firmansyah and Subriadi, 2022). Once a user's query reaches Level 3 support, the specialists analyse the code and designs thoroughly to identify the root cause of the problem. They can handle a wide range of technological challenges. If necessary, the technicians may raise a problem with the organisation to implement changes to the system and submit fixes to Levels 1 and 2 support (Firmansyah and Subriadi, 2022). The third level of support is the CSIR personnel. They do not deal directly with any users and/or technicians. The CSIR agents use TeamViewer to resolve the support query remotely. If necessary, the resolution is communicated to Level 2 support, and the solution is added to the knowledge base.

14.5.3 Support Queries Resolution in System Maintenance

According to Han, Li, and Sun (2020), a support query is a text document that includes an incident report. A key aspect of system maintenance is the handling and reporting of support requests. Support queries serve as a means of monitoring the system and arranging maintenance activities (Zhou, Xue, Baral, Wang, Zeng, Li, Xu, Liu, Shwartz, and Ya. Grabarnik, 2017). To facilitate this, users can submit support requests through a ticketing system (such as osTicket) (Montgomery, Damian, Bulmer, and Quader, 2018). Gupta (2019) notes that support queries are typically composed of structured fields such as reporter, reporting time, priority, and agent and unstructured fields such as descriptions, comments, and attachments. Analysts (such as developers) handling the support queries may require consulting additional repositories to resolve the query, such as the source code and revision history (Zhou et al., 2017). This section discusses the stages in the lifecycle of a support query to assist in resolving the query (Zhou et al., 2017).

14.5.4 Support Query Lifecycle

There are several stages in the resolution lifecycle for support queries, including assigning the query to the appropriate agent, assigning the query to the appropriate software component, requesting information from the reporter, resolving the issue, and closing the support request (Gupta, 2019). The stages can be broadly classified into the following primary phases.

- Support query understanding: To effectively handle a support query, it is important to understand it first. This involves analysing the query to identify any duplicates, determining its priority and severity level, and other relevant variables (Han et al., 2020). From the initial understanding of the query, the entire process of resolving the support query can be streamlined and made more efficient. Therefore, a complete understanding of the support query is required during the entire process of resolving it.
- Support query assignment: Once the support query has been fully comprehended, the support query must be assigned to the appropriate individual (Shah, 2021). Assigning support queries to a suitable agent avoids multiple reassignments, can decrease the likelihood of resolving the problem and lower support quality (Mandal, Malhotra, Agarwal, Ray, and Sridhara, 2019).
- Support query fixing: To resolve (fix) a problem, an agent assigned to a support query must execute the appropriate steps that may need to be discussed with the reporter (Zhou et al., 2017). Code changes might be required to fix some issues. In light of this, an agent creates a patch and adds it to the finished code base.

14.5.5 Phases for Resolving Support Queries

This section presents phases to follow when resolving support queries. The purpose of these phases is to make the process of addressing support queries easier for the support and maintenance team

while reducing the backlog. These phases are derived from the previously stated stages of the support query lifecycle to assist in addressing support queries based on the degree of urgency of the request.

- Priority Prediction: Support queries have a structured field called priority, with categorical values ranging from highest to lowest priority (Bani-Salameh, Sallam, and Achieng, 2021). It assists developers in prioritising support requests, meaning the most critical ones receive more attention (Paramesh, Ramya, and Shreedhara, 2018). Priorities in the HPRS are described in the SOP document and made available to support levels. When responding to a request, all support agents must refer to the SOP to determine the priority level appropriate for that request. Agents must classify the queries into four (4) priority levels: critical, high, medium, and low (Steenkamp et al., 2017).
- Severity Prediction: Another specified field for bugs and support queries is severity, which specifies how much impact they have on functionality. This prediction requires specialised knowledge to assess the impact of a support request through human examination (Rodríguez-Pérez, Gonzalez-Barahona, Robles, Dalipaj, and Sekitoleko, 2016). The HPRS support team comprises professionals with various skill sets who can predict the severity of bugs and queries of the health system's functionality and the whole HPRS environment. This chapter, however, advocates investing in skills-based sets for the support and maintenance team, which will advance and enhance the teams' performance and improve the overall system.
- Reopen Prediction: Reopening a support query is possible for several reasons, including regression bugs, incorrectly fixed bugs, and the availability of new information to improve understanding of the problem (Bani-Salameh et al., 2021). The HPRS support team strives to ensure queries are fully addressed with no room for error when resolving a request. There is hardly a case where support queries had to be reopened, but should there be a need for this prediction, the team will act accordingly to ensure user satisfaction and system improvements.
- Support Query Assignment: It is crucial to assign a support query to an appropriate developer so they can address it (Qamili, Shabani, and Schneider, 2018). The likelihood of reassignments can be decreased and the waiting period for selecting the best developer can be shortened by automatically assigning support queries (Gupta, 2019). Developers of the HPRS already know the different kinds of queries they each address. The 3rd level support agent escalates queries to a group of developers using ICT platforms such as MS Teams and WhatsApp. In these platforms, the developer responsible for the request will handle it.
- Support Query Fixing: Assignees investigate the reported issue to see if a code change is necessary (Gupta, 2019). This is evident in the HPRS environment, where the HPRS developers are always working on improvements and health system enhancements and conducting user acceptance testing to ensure system functionality before deployment.

- Bug Localisation: Changes to the code may be necessary to address some bugs. The designated developer is required to localise it. To localise bugs, one must have a solid understanding of the bug and the code base (Rodríguez-Pérez et al., 2016). The HPRS developers can remotely access the Virtual Machines of healthcare facilities using Team Viewer. To address a bug, developers can investigate it and determine if it is resolvable, or a code change is required. Every release deployed for the system improvement addresses bugs that required a code change.
- Patch Generation: Engineers must create code fixes to address the problems (Xiong, Liu, Zeng, Zhang, and Huang, 2018). Test cases are needed to evaluate the patch and determine which one is right. Making educated decisions on process improvement requires understanding the true state of the process and locating inefficiencies (Long and Rinard, 2016). All the versions ready for deployment undergo intensive testing, and there are always code fixes for every bug in the HPRS.

14.5.6 Skills-Based Set Practices

Skills are the qualities required to execute a task. According to Braňka (2016), skills refer to the ability of an individual to perform tasks and duties of a given job accurately and confidently. Skills-based sets combine practical knowledge, clarity, competence, dexterity, and the ability to perform a function that can be achieved or learned at schools or training centres through study and experience (Frischmann, 2020). Some technical skills are unique to a particular discipline. These technical abilities are frequently separated into subskills that apply to specific languages or technologies (Frischmann, 2020). This has been observed with the HPRS, which is based on a Linux/Ubuntu platform, and as such, most support staff are not familiar with the language and environment enough to understand how the system functions. While skills are important in making decisions about work, Cantrell, Griffiths, Jones, and Hiipakka (2022) argue that organisations cannot focus solely on skills. There is a need to shift to a skills-based practice, an evolutionary journey that lets people's uniqueness as humans shine through, with work tailored to their strengths (Cantrell et al., 2022).

In skills-based practices, employees emphasise their specific (capabilities) abilities, knowledge, and skills more than their job title, academic attainment, degrees, or previous experience (Köppen, 2023). The practice can be applied in employee recruitment, career development, growth and retention (Ward, Jackson, Newsome, and Kaplan, 2023). Implementing skills-based practices has many organisational benefits. The program can improve key business outcomes, improve skills intelligence, provide valuable insight into skill gaps, and enhance talent engagement and retention for employees who wish to work for organisations that invest in keeping skills relevant (Devine and Andretta, 2022). Mercer (2023) finds encouraging progress among organisations that have adopted platforms and data to drive skill-based strategies. Though such an approach is complex and takes time, many models and frameworks have been developed to assist organisations in skills-based practice implementation.

14.5.6.1 The Importance of Skills-Based Sets

The development of employee skill-based sets plays a crucial role in the growth and success of an organisation. As a result of advanced skill-base sets, employees can be more productive, innovative, efficient, and adaptable to new technologies and techniques (Kumar and Siddika, 2017). Knowledge, talent, and attitudes of employees with the requisite skill-base sets allow them to function satisfactorily in their positions. Additionally, it ensures employees' efficient performance by improving their ability to adapt to the demanding and growing corporate environment and technology (Moges, 2018). A skill-based set tailored to the needs of the workplace can assist in closing the performance gap between expectations and actuals. Employees become more creative and analytical, making better judgments quicker and more efficiently (Flegl, Depoo, and Alcázar, 2022).

Furthermore, skill-based sets are required to provide efficient, effective, customer-focused service desk support. Organisations may optimise resource allocation, reduce issue resolution times, boost customer satisfaction, and drive continuous improvement in IT support operations by using support personnel talents and expertise. The achievement of company goals appears to be reliant upon employees possessing sophisticated skills (Burhan Ismael, Jabbar Othman, Gardi, Abdalla Hamza, Sorguli, Mahmood Aziz, Ali Ahmed, Sabir, Ali, and Anwar, 2021).

14.5.6.2 Enhancing Skills-Based Sets

Organisations use training and development to bridge the skills gap in their workforce. These skills are essential for an individual to conduct their work effectively and make an excellent contribution to the team. According to Alkhatib (2019), a learning skill is the ability to absorb basic concepts and knowledge in a range of cognitive (thinking), affective (emotional), and psychomotor (physical) contexts. In addition, the author defined learning skills as *a combination of ability, knowledge, and experience that is subject to intentional development and enables a person to do something well within a specific situation* (Alkhatib, 2019: 46). A new skill involves putting in the necessary time and effort to create something valuable, accepting moral, financial and social risks, and realising your full potential and becoming independent (Muogbo and Obananya, 2022). Various approaches, including peer cooperation, coaching and mentoring, and subordinate engagement, can be used to provide training and improve the skill-base set of employees (Kumar and Siddika, 2017). A few of these strategies will be explored in the following subsections.

- Training*:* Through a skills-based training program, organisations can recruit and retain their employees more effectively (Hancock, Higgins, Law, Olson, Patel, and Van Dusen, 2022). Organisations can expose employees to the real-world experiences of working on the job to build a pool of more resilient and better-prepared employees. Campanella (2023) asserts that skills-based training allows individuals to gain real-world experience through hands-on training and real-world application. Through skills-based training, employees learn to analyse and solve problems, develop creativity, innovate ideas, and collaborate with peers.

The degree/diploma qualification should be removed from job requirements by organisations interested in skills-based training to ensure sustainable skills-based training (Hancock et al., 2022). While degree qualifications may be eliminated from certain positions, it is necessary to maintain a balance between formal skills training and skill-based training. In addition to skills-based training, knowledge-based learning should be balanced so employees can be assessed using traditional assessments such as exams, tests, and other assessments. Thus, skills-based training should be complemented by knowledge-based training to develop individuals holistically, as one focuses on real-world practical training while the other focuses on acquiring facts and academic information (Campanella, 2023). Having personnel that can adapt to changing circumstances and respond to problems quickly is essential for managing problems in healthcare facilities. For HPRS IT services to be always available, there must be peer-to-peer collaboration between the development and support teams. Moreover, if personnel training is required, the management provides technical training on relevant technologies, tools, and processes, as well as soft skills training on communication, problem-solving, and customer service needed to carry out their daily tasks.

- Mentoring and Coaching to Supporting Skills-Based Training*:* Mentorship in healthcare training is highly recognised. It improves staff performance and engagement, expands learning possibilities, and encourages multidisciplinary collaboration (Burgess, van Diggele, and Mellis, 2018). Burgess et al. (2018) further state that mentoring is a coaching and educational role that requires generosity of time, sensitivity, a willingness to share knowledge and abilities, a passion for teaching, and contributing to others' success. Thus, mentoring significantly impacts personal growth, career guidance, and professional choices (Burgess et al., 2018). In the HPRS support environment, there has been a need to hire personnel who can respond to the growing amount of support requests from healthcare facilities using the HPRS. New personnel are allocated mentors and coaches to fully support healthcare facilities and facilitate a smooth transfer of skills, particularly when dealing with HPRS queries. Manzi, et al. (Hirschhorn, Sherr, Chirwa, Baynes, Awoonor-Williams, Hingora, Mboya, Exavery, Tani, Manzi, Pemba, Phillips, Kante, Ramsey, Baynes, Awoonor-Williams, Bawah, Nimako, Kanlisi, Jackson, Sheff, Kyei, Asuming, Biney, Chilengi, Ayles, Mwanza, Chirwa, Stringer, Mulenga, Musatwe, Chisala, Lemba, Mutale, Drobac, Rwabukwisi, Hirschhorn, Binagwaho, Gupta, Nkikabahizi, Manzi, Condo, Farmer, Hedt-Gauthier, Sherr, Cuembelo, Michel, Gimbel, Wagenaar, Henley, Kariaganis, Manuel, Napua, Pio, and the (2017) posits that partnering experienced and recruits addresses the difficulties that recruit face when transitioning from theory to practical real-time environment. New recruits for support and maintenance are typically freshly trained university graduates who must be transferred into the practical route; consequently, mentors and coaches can help the recruits shift from class to practice. The process must be monitored and evaluated continuously to ensure that both mentor and mentee benefit from the relationship. Mentoring and coaching should occur at all support levels to ensure that every

new entrant in the support and maintenance environment is equipped with the necessary skills to resolve support queries in the shortest time possible. According to the Commission on Education Training for Patient Safety (2016), learning from incidents, best practices, and case studies should be made more accessible to those providing education and training to guarantee that lessons learned are applied to all new and future recruits. Training materials for support and maintenance personnel should be updated as needed to ensure that all the latest system enhancements are included in the manuals and accessible to all who need to be trained as well as those who can use the manual to improve themselves. As the Commission on Education Training for Patient Safety (2016) report states, recruits and experienced personnel should have access to all essential training resources, including the processes and tools utilised to support and maintain the HPRS system. Although human aspects can be challenging, support and maintenance personnel (both new and experienced) must comprehend the system's goal and purpose. All personnel ought to understand that at the centre of all health systems, they must ensure that all patients receive the care they desire from healthcare facilities and that the healthcare systems available do not obstruct the provision of health services (Commission on Education Training for Patient Safety, 2016).

- Online Courses*:* Online learning has always existed, but it was done on a limited scale because people could physically attend training, development, and evaluation sessions. However, COVID-19 has emphasised the need for improved online training, development, and assessments in various contexts, including education, labour, and health. People can learn online anytime and from any location, providing flexibility. Online learning has the following benefits (Gautam, 2020):
- Affordability – online courses are more cost effective than the traditional courses that are attended physically.
- Flexibility – self-paced learning for people who enroll in online courses.
- Accessibility – anyone with internet connectivity can access any course, anywhere and anytime.
- Variety - Many courses and skills-based training options are available for online learning.
- Time management – individuals can select courses that align with the skills they need to execute their jobs. Employers can also benefit as they can enrol their employees on flexible online skills-based training and development.

Through the European Health Parliament (2016), the European government has also established a committee to ensure that all of its healthcare personnel gain digital skills and can utilise technology responsibly, with the patient at the forefront of development. The committee would also ensure that healthcare professionals and patients are co-creators in institutionalising mHealth and eHealth; this could be a direction South Africa takes to ensure that no one in the healthcare food chain is

left behind as their processes and systems are digitised. Numerous online courses are available to enhance skills-based sets in various areas relevant to service desk support and IT operations. Depending on the individual needs and areas of interest, courses can be chosen to correspond with personnel goals and skill development objectives. Furthermore, many of these platforms include free trials or subscription-based access, making exploring various courses and learning paths simple.

14.5.6.3 Skills-Base Sets Needed for the Efficient and Effective Resolution of Support Queries

An ICT service desk is the central point of contact for everyone involved in resolving IT operations, support and maintenance queries. The set-up of an IT service desk requires that the personnel appointed for this role have IT service desk skills-base set to ensure smooth running of the help desk as well as achieve maximum customer satisfaction. IT specialists employed in support and maintenance need soft and hard skills to respond and resolve queries effectively and efficiently in the shortest time possible (Szilárd, Benedek, and Ionel-Cioca, 2018). The soft skills refer to the human related skills like creativity, problem solving, analytical skills, communication, teamwork, collaboration, etc., while the hard skills refer to the technical knowledge needed to resolve ICT queries. Unlike hard skills, usually technical skills, as mentioned earlier, soft skills are non-technical and harder to measure and quantify (Byrne, Weston, and Cave, 2020). The literature emphasises the areas of focus for the successful execution of ICT support and maintenance, such as *management skills*, *people skills*, *processes* and *technology*. People skills are what other authors call soft skills; these are the ability of a team to collaborate, communicate, and share knowledge of the environment in which they work. They are usually developed through social experience (Lamri and Lubart, 2023). The process factors are the repeatable procedures and processes documented on how to solve support queries, which must be followed consistently and are continuously improved to respond to the changing world of ICT as well as the type of support queries being escalated at various levels (ITIL, 2019). Management factors refer to the management's commitment to having clear strategies for implementing ICT support within an organisation (Agbo, 2015; Dewah and Sibanda, 2022). The technology factors refer to the tools that are used to carry out ICT support effectively (Rajan, 2018). In conjunction with soft skills, support personnel must be equipped with hard skills such as *problem-solving techniques* (Dion, 2024:2)*, customer service foundations* (Toister and Toister, 2023:57) and *Ubuntu Linux server basics* (Miller, 2020:32). In the support field, knowledge of these skills allows the support personnel to focus on developing their soft skills for effectively resolving support and dealing with customers. A support agent who can resolve raised queries quickly is knowledgeable about their processes and can improve customer satisfaction. As mentioned, the HPRS environment is based on a Linux/Ubuntu platform.

As such, support agents have acquired training in the language and environment to enable them to solve client-based queries.

14.6 The Results

A survey study was conducted to obtain a comprehensive view of how skills-based sets play an important role in solving support requests and the overall HPRS system. This information was gathered from ten (10) professionals in the support and maintenance industry. The professionals presented with the survey questions (SQ) are from different support levels of the HPRS Support and Maintenance team and are all exposed to the various support tickets logged by end users. Consequently, this section presents the survey findings of the different viewpoints of the participants based on their level of expertise.

All participants agreed with the statement. Figure 14-3 indicates that 80% of the participants strongly agree.

1. Skills-based set ensures that personnel can proactively and efficiently perform at their best in their respective roles. Please rate the statement based on your experience and on your knowledge.

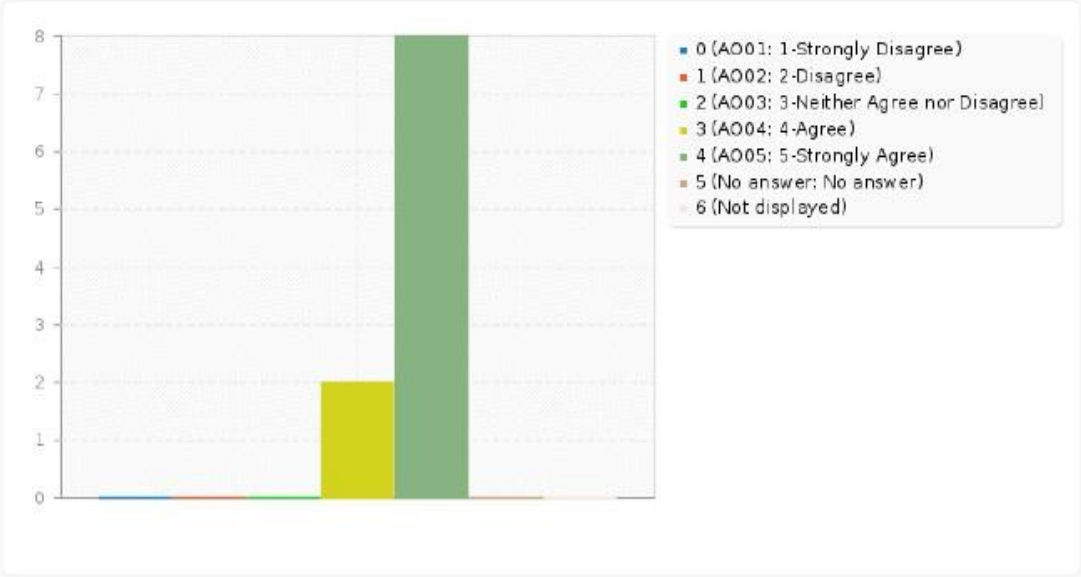

Figure 14-3: Results for SQ1

In Figure 14-4, it is shown that 70% of participants strongly agree with the statement. While 30% only agree.

2. Lack of skills-based set can result in the inefficient support queries resolution. Please rate the statement based on your experience and on your knowledge.

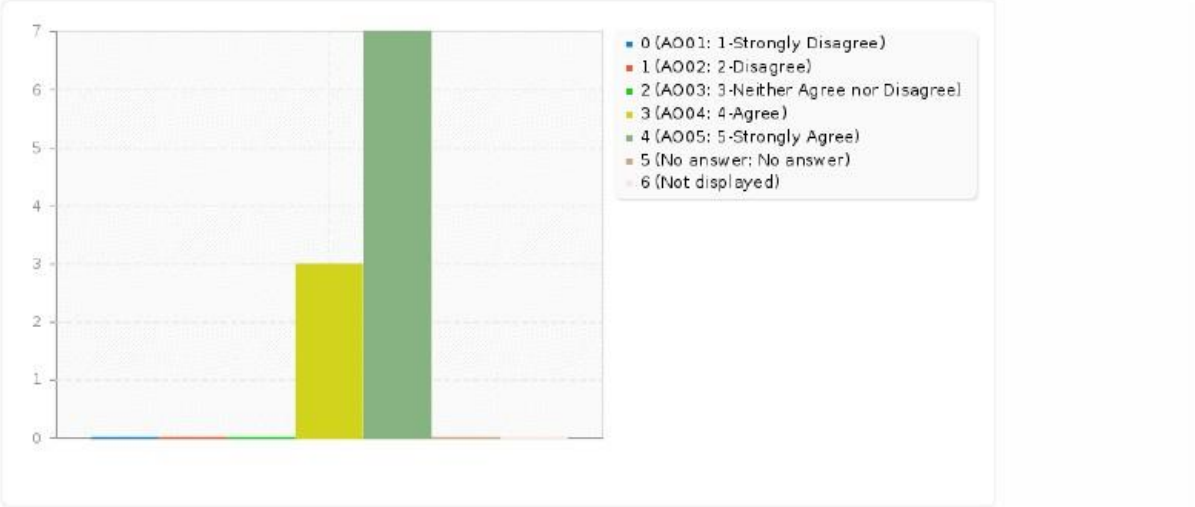

Figure 14-4: Results for SQ2

Figure 14-5 shows that 80% of the participants strongly agreed with the statement.

3. Skills-based set ensures that support queries are routed to the right people who have the right expertise to resolve them efficiently. Please rate the statement based on your experience and on your knowledge.

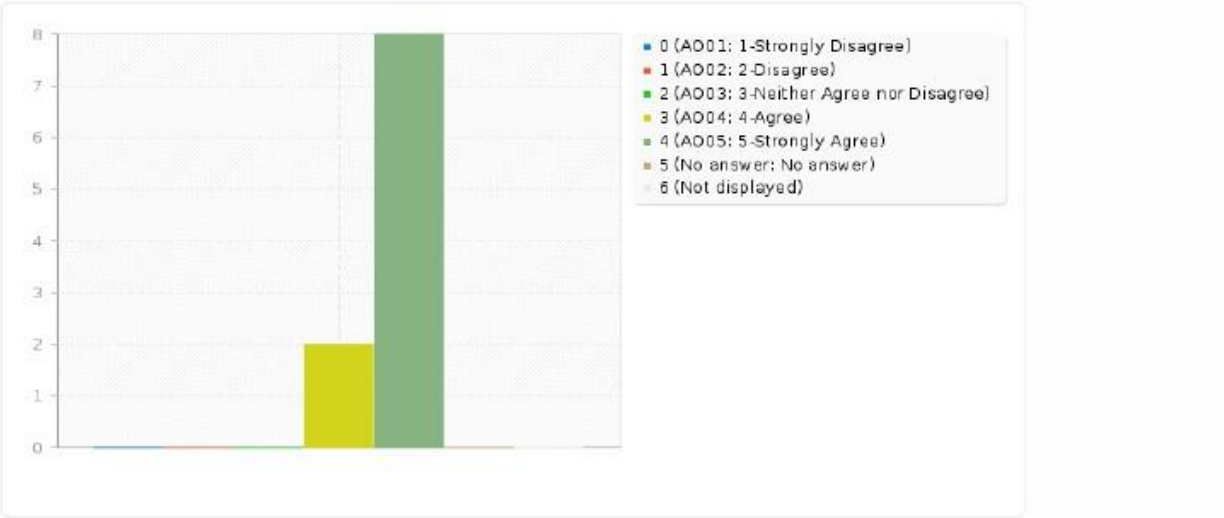

Figure 14-5: Results for SQ3

As illustrated in Figure 14-6, 70% of the participants strongly agreed with the statement.

4. By matching support queries with skilled personnel, end-users can be provided with quicker and more accurate solutions leading to enhanced customer satisfaction. Please rate the statement based on your experience and on your knowledge

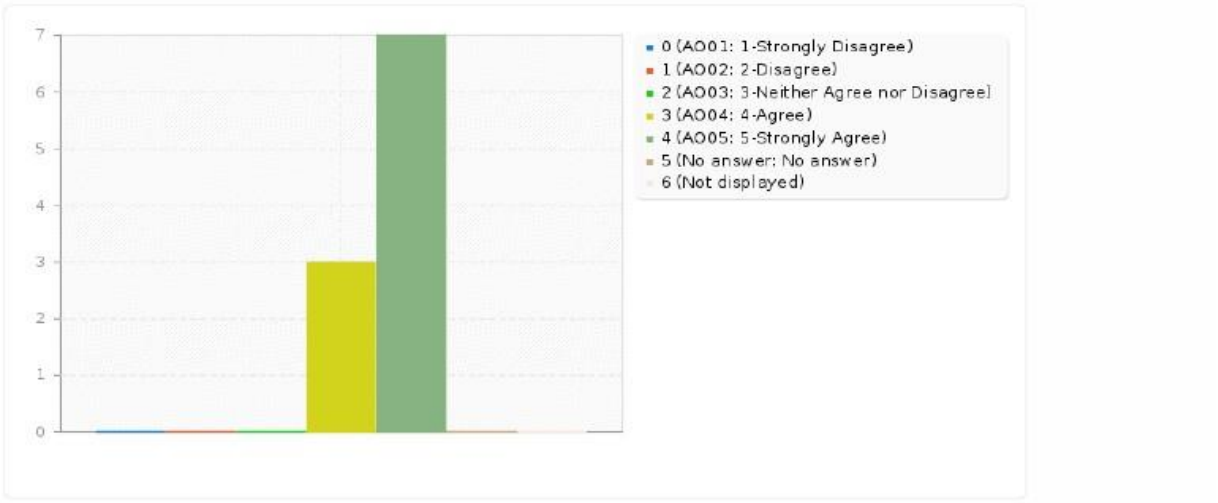

Figure 14-6: Results for SQ4

Figure 14-7 illustrates that 60% of the participants strongly agreed with the statement.

5. Skills-based approaches facilitate the resolution of issues at the initial support level without the need for unnecessary escalation resulting in reduced escalations. Please rate the statement based on your experience and on your knowledge.

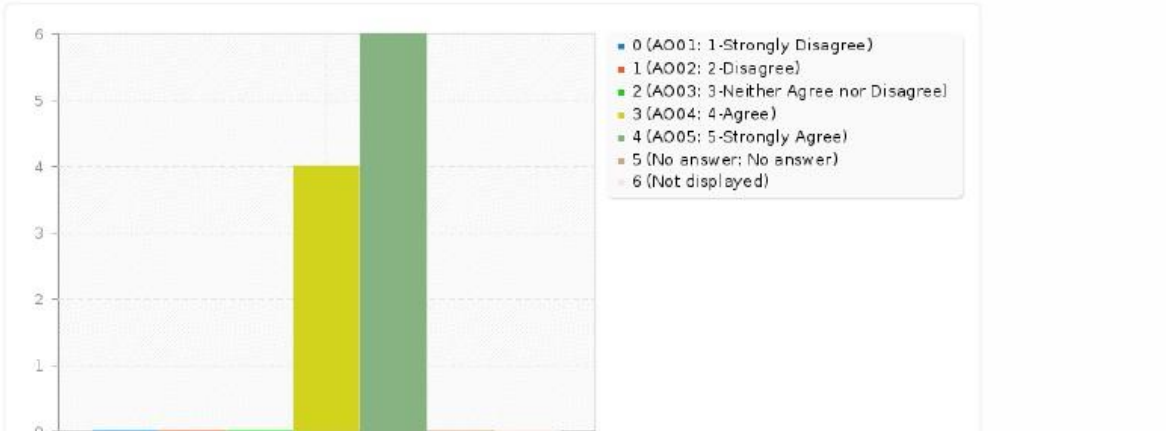

Figure 14-7: Results for SQ5

It can be seen in Figure 14-8 that 60% of the participants strongly agree with the statement and 10% of the participants disagree.

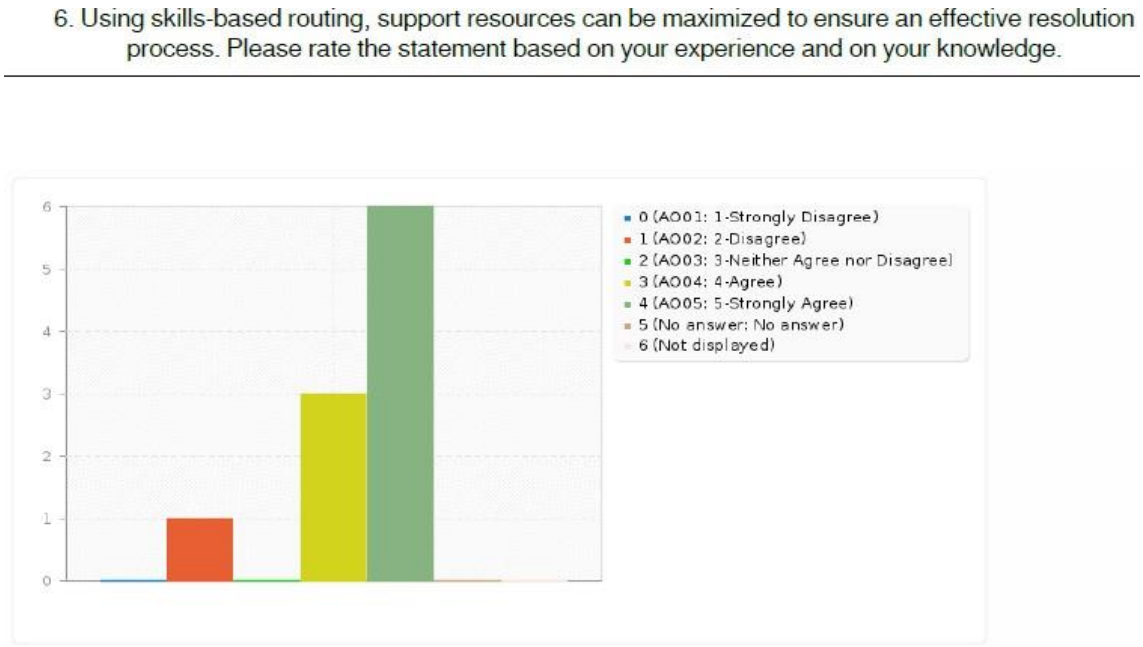

Figure 14-8: Results for SQ6

Figure 14-9 shows that 70% of the participants strongly agreed with the statement.

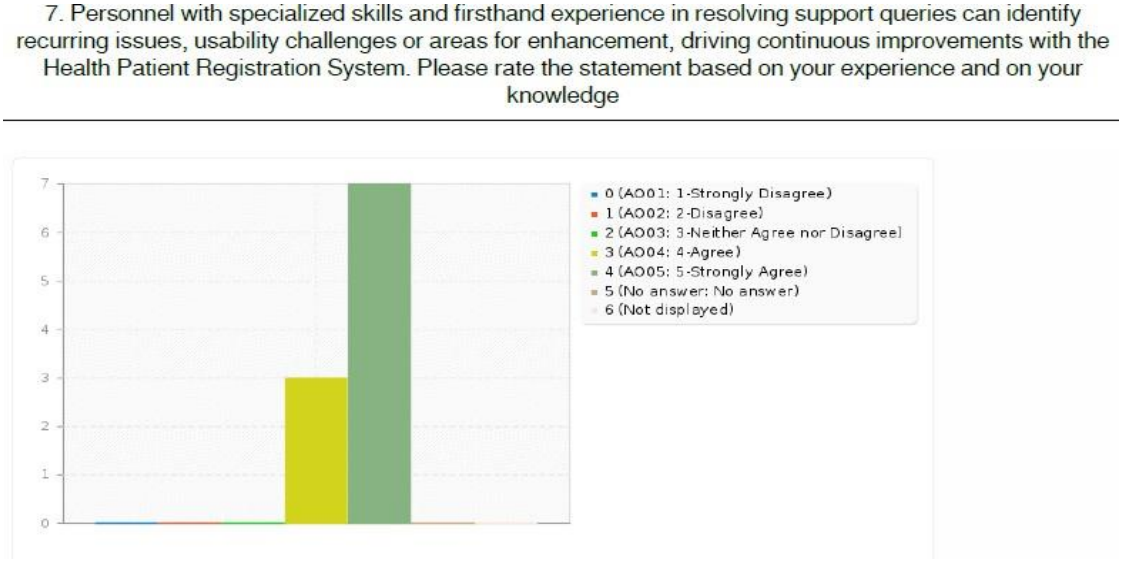

Figure 14-9: Results for SQ7

According to Figure 14-10, 80% of participants strongly agreed with the statement.

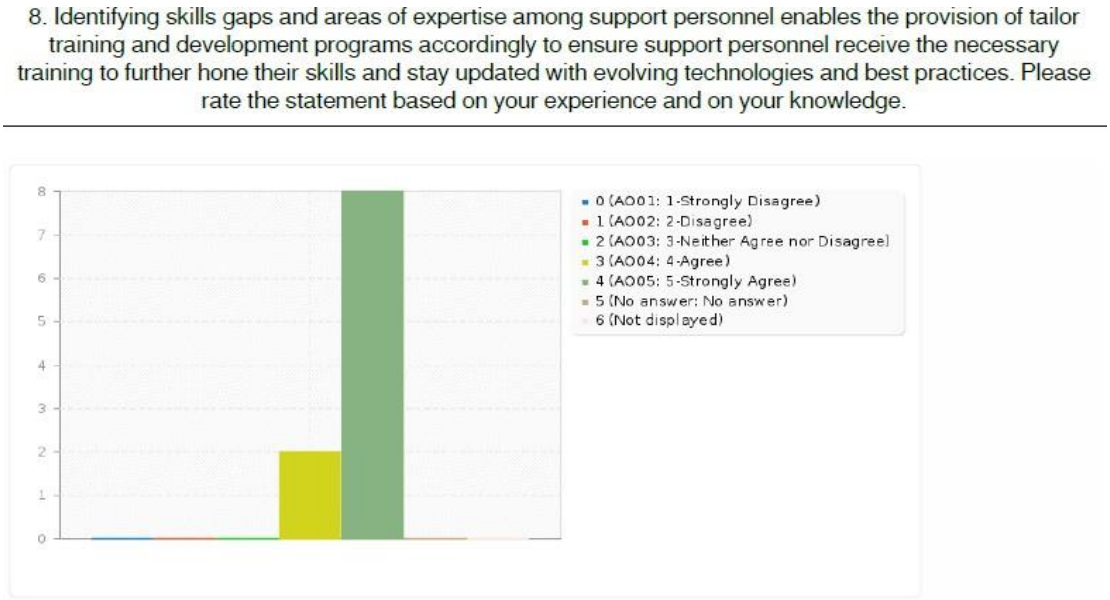

Figure 14-10: Results for SQ8

Based on Figure 14-11, 50% of participants strongly agreed with the statement. 40% of the participants only agree, while 10% of the participants neither agree nor disagree

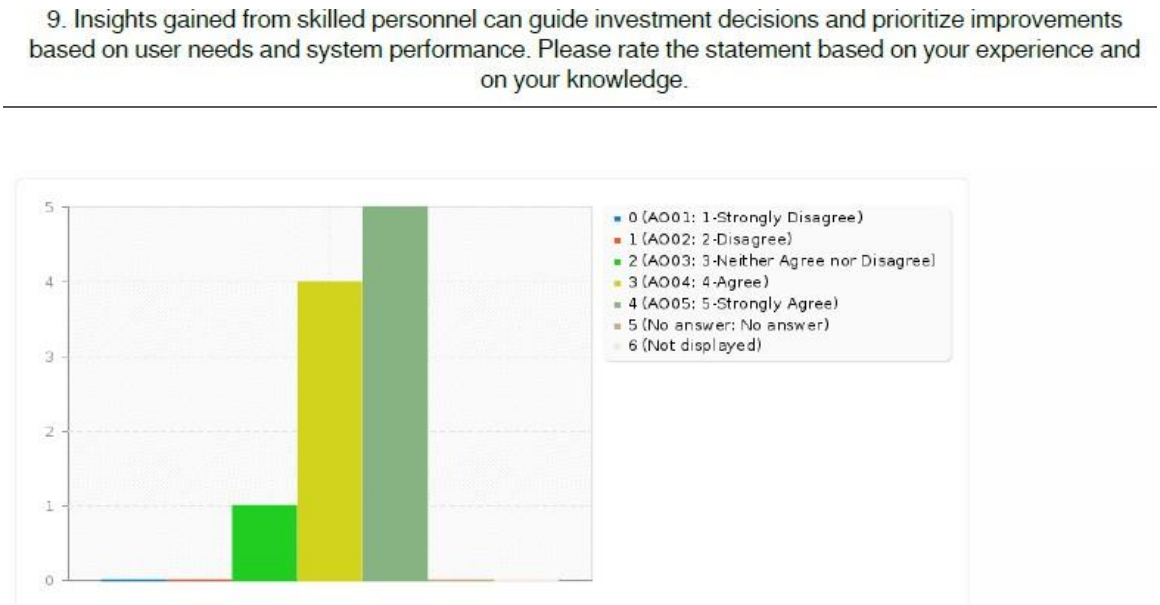

Figure 14-11: Results for SQ9

14.7 Discussion of the Results

The online survey was conducted primarily to gather lessons learned and experiences while using HPRS in the service desk support environment. Based on the survey questions (SQ), the participants gave inputs and insights on the importance of a skills-based set in effectively and efficiently solving support queries and, ultimately, the continuous improvement of HPRS within the maintenance and support environment. In this section, the researchers reflect on the results obtained from the Lime Survey. The result of the survey complements the literature review in that participants demonstrate a positive response on the importance of a skills-based set.

> *SQ1: Skills-based sets ensure that personnel can proactively and efficiently perform at their best in their respective roles.*

In the participants' opinion, it was felt that the right skills can allow anyone, regardless of their role, to perform efficiently. As a result of skills-based sets, service desk support can be minimised in time and improved in effectiveness. They allow individuals to identify an issue immediately due to their understanding of what they are doing. The individual can apply several methods of resolving a specific issue because of a strong skills-based set, ensuring that personnel perform at their best. Employees can proactively initiate the maintenance process through training and development before problems occur. Nagy, Pelser, and Vaiman (2022) concur with the sentiments and further emphasise that skills-based sets are critical to the success of global businesses.

> *SQ2: Lack of a skills-based set can result in inefficient support query resolution.*

Without a skills-based set, participants felt that support queries may not be directed to the appropriate personnel with the required expertise to resolve them effectively. Support queries can be delayed as a result, leading to frustration among users. Without training and empowerment, individuals lack the confidence and skills to deal proactively with support issues and problems they encounter at work. According to Collaborative Partnership (2019), empowering individuals with skills-based sets can improve economic outcomes for individuals, their families, and the community. Lacking skills-based sets can result in inefficient support query resolution; thus, the escalation of tickets is important when you cannot resolve a support query, and it minimises the time it takes to resolve the issue when you do not possess the necessary skills. The fast-growing field of ICT makes continuous training and development a critical component of the support and maintenance environment.

> *SQ3: Skills-based set ensures that support queries are routed to the right people with the expertise to resolve them efficiently.*

Participants believed that with the proper skill-base sets, support agents know how much troubleshooting is required and who to escalate to. Individuals who have been taught and can comfortably handle support queries can escalate when they realise the problems are beyond their

expertise. Participants reported that knowing their skills-based sets allows faster and more efficient resolution of queries by routing them to the appropriate persons. As an example, one participant remarked that

> *On HPRS, we sometimes get support calls where you know what the issue is, but you are not the person to approve if approval is needed for that., so having the skills to identify the issue quickly ensures that the issue is escalated to the right personnel timely.*

This guarantees that the correct people are performing the proper duties, resulting in more efficient support operations, increased customer satisfaction, and a better overall support experience.

> *SQ4: By matching support queries with skilled personnel, end-users can be provided with quicker and more accurate solutions, leading to enhanced customer satisfaction.*

There are varying skill sets within a support team, which means that the best person for the job is assigned to attend to the matter, ensuring a shorter amount of time is used to resolve a query. The strategic matching of support queries with skilled personnel ensures efficient support. It plays a crucial role in creating a positive and satisfying customer experience, as users receive timely and effective assistance with their queries or problems. As observed by the participants, skilled personnel improvise on HPRS because they can search for solutions on Google and resolve the issue even when they are stuck along the way. On Google, they can identify the relevant solutions to the problem while if you lack skills-based sets, it is very difficult to identify the relevant solution to your problem. Responsiveness, empathy, and assurance are influential to customer satisfaction (Johnson and Karlay, 2018). These are qualities observed in the HPRS support and maintenance environment.

> *SQ5: Skills-based approaches facilitate the resolution of issues at the initial support level without the need for unnecessary escalation, resulting in reduced escalations.*

Participants concur that if the first support level has adequate skills to resolve the tickets, they should be resolved at their level. Only pertinent tier-level support queries should then be routed to the appropriate level. The respondents also state that unnecessary query escalation results from a lack of training at the lower support levels. According to them, this results from a lack of comprehension or insufficient system expertise. For instance, one participant said,

> *A user can log a ticket stating that they cannot access HPRS. This site cannot be reached when they attempt to open HPRS; a skilled-based agent should be able to handle the problem without escalating it to the next level of support.*

There was a general consensus that at the first support level, technical support is trained to ensure that investigations and basic troubleshooting of all queries logged are conducted and a diagnostic report is generated. Training should be provided at the different levels of support to ensure

everyone understands the extent of their work and when to escalate issues to resolve them as quickly as possible. However, there are situations where personnel should be able to find solutions, as training cannot prepare one for all eventualities. A different participant stated:

> *My experience on HPRS is that sometimes it happens that I work on the ticket that I know should have resolved at the first support level.*

A skills-based practice significantly contributes to resolving issues at the first support level, resulting in a more efficient, cost-effective, and customer-centric support environment.

> *SQ6: Using skills-based routing, support resources can be maximised to ensure an effective resolution process.*

The statement received general approval, with most respondents agreeing that employing skills-based routing may help organisations maximise their support resources. One person remarked that

> *...this allow for more time to be afforded to specialised skilled support to deal with more complex queries*

Another participant said,

> *...by using a skills-based routing, organisations can maximise their support resources, streamline the resolution process, and ultimately provide a more effective and satisfying customer support experience*

Mirenda (2024) agrees with the respondents and believes that organisations may employ skills-based routing to streamline ticket handling and ensure that users speak with the agent best suited to fix their issues. However, one responder disagreed, saying that

> *...personnel who lack skills-based sets would never be able to increase their skill sets through skills-based routing as they won't receive enough support queries to work on and practice to improve their skills. Meaning that highly skilled personnel will be overloaded with support queries*

The respondent further states that on

> *HPRS, if you can't resolve the VM issues, it means that personnel with the skills to work on the VM issues are going to work on multiple VM issues at a time even if you are available to assist, you can't because you lack the skills-base set of the VM.*

SAS (2019) agrees with the responder above, noting that skills-based routing can result in prioritising recent calls over older ones.

SQ7: Personnel with specialised skills and firsthand experience in resolving support queries can identify recurring issues, usability challenges or areas for enhancement, driving continuous improvements with the Health Patient Registration System.

The majority of the participants agreed with the statement. They stated from personal experience that

> *experience is the best teacher; however, it must be augmented by continuous training and development of personnel as systems are improved and developed to meet the needs of end-users*

A similar response went on to say, "*I can easily identify, troubleshoot and implement the best possible resolution as I have repeatedly supported various sites and environments firsthand".* A different respondent reported that recurring issues, such as *syncing*, *database errors*, etc., are common in the support environment and in different time frames. Identifying these recurring issues can assist in establishing patterns that may enable the agent to determine the root cause.

SQ8: Identifying skills gaps and areas of expertise among support personnel enables tailored training and development programs to ensure they receive the necessary training to hone their skills further and stay updated with evolving technologies and best practices.

It's important to acknowledge that no matter how dedicated one may be, becoming an expert in every skill required to excel in their profession is impossible. Instead of trying to do everything alone, delegating tasks to others with expertise in those areas is better. Doing so lets you focus on your strengths and improve your work. One participant shared similar sentiments and stated:

> *A person can never fully know all the required skills to do their job efficiently. Actively upskilling personnel based on the gap will help develop the right support personnel and thus improve the overall support and maintenance rendered to system users.*

Additionally, a different participant suggested:

> *Identifying skills gaps and areas of expertise and tailoring training programs accordingly, one can ensure that the support agents are well-equipped to provide effective assistance, stay updated with the latest technologies, and deliver optimal support for the Health Patient Registration System.*

A participant emphasised that recognising skill gaps in personnel is crucial to improving talents, especially in a vast system like HPRS. They stated:

What happens on HPRS is that different support levels only know what they are responsible for on their respective levels, which limits them from understanding other parts of the system.

Over time, advancements in technology require updated methods to address problems that arise. Technicians must receive comprehensive training and upskilling to handle these changes effectively. Furthermore, it is imperative that workers receive continuous training when ICT systems are improved to ensure they are well-versed with the updated system and can resolve any issues that may arise promptly. Regular training and development can be used to assess the skills of employees and identify individuals who require additional training. This ensures that employees are equipped with the necessary skills to perform their duties effectively and efficiently.

SQ9: Insights gained from skilled personnel can guide investment decisions and prioritise improvements based on user needs and system performance.

The participants agree with the statement because support queries and resolutions can provide valuable data for strategic decisions about system enhancements, updates, and future development. Skilled personnel will identify the issue and try to investigate its root. As a professional, it's crucial to have the ability to recognise and solve problems. Skilled personnel understand this and are trained to identify issues and determine their root causes. By doing so, they can tackle the problem head-on and develop effective solutions. One participant stated:

An example was the syncing issue on HPRS in 2023, where the facilities were not syncing. Later it was discovered that the time was behind on the central local server. That really help because the problem was resolved, and the facilities were syncing as usual, which reduced a lot of syncing issues at the time.

Another mentioned:

Users should be able to propose future investments since they understand the system's obstacles and growth opportunities. In addition to improving user satisfaction, this technique helps the healthcare registration process run smoothly and successfully over time.

To summarise, skill-based sets are critical for assuring growth, relevance, and accuracy. A skill-based set is crucial for providing efficient support, enhancing customer satisfaction, maximising resource usage, driving continuous development, and influencing strategic decision-making processes for the Health Patient Registration System. Organisations can provide superior support services while also contributing to the continuous improvement of system functioning and usability by harnessing the expertise of skilled personnel. A skill-based set simplifies the support process and is the foundation for user-centric development and adaptation to changing needs. It is

critical in guaranteeing the Health Patient Registration System's performance and success. The most crucial factor in ensuring the effectiveness of the training is determining the skills gaps or lacking skill sets. The second support level personnel must be trained in what the first support level personnel must know and what the second support level must know to prevent needless escalation of support queries. The third support level team must be trained in everything related to the system, as they are the last in charge of providing resolution to support queries. This will ultimately lead to user satisfaction and build trust with clients.

14.8 Recommendations

The recommendation section is based on the skills-based sets required to solve support queries while improving the HPRS environment efficiently. The phases of resolving support queries and the results from the survey highlight some key skills-based sets that are needed, and these are mentioned below:

Analytical skills:

These are soft skills that aid in identifying and solving difficult challenges (Rahman, 2019; Mitsea, Drigas, and Mantas, 2021). Although an SOP document guides the HPRS support, the support team needs to apply analytical thinking in every query to determine if a support request needs priority, severity, or reopen prediction and to whom the request should be assigned.

Communication skills:

These are required to speak effectively with a wide range of individuals while maintaining strong eye contact, displaying a diverse vocabulary, and tailoring your words to your audience (Radovic Markovic and Salamzadeh, 2018). This skill is critical in the HPRS and must be enhanced as a lot of misunderstanding may occur. The different support team agent must be able to communicate with the system's end users, the different tier levels of support and the developers to successfully resolve support queries.

Time management skills:

This is the process of managing and planning how to divide one's time across various tasks (Wolters and Brady, 2021). The HPRS support team needs this skill to consistently manage their time across different tasks as there are days when support queries are too many and very few resources to attend to. Time management skills will assist with resolving support queries as efficiently as possible.

Interpersonal skills:

This will allow the HPRS support team to interact physically and online with other departments and clients and convey information simply and succinctly while maintaining strong connections.

Basic developer skills:

This requires basic practical programming and code-writing knowledge. This skill is particularly important for the 3rd level support agent as these personnel directly escalate requests to the developers of the HPRS. This skill will assist the agent in identifying any bugs that may require code fixes, patches, and which bugs can potentially harm the system. Online courses such as Udemy and mentorship offered by HPRS developers can assist with enhancing this skill and improve the system in the future.

- Adaptability skills: This will allow the HPRS support team to adjust to the ever-changing HPRS technology system functionality.
- Problem-solving skills: This includes critical thinking, decision-making, creativity, and information processing. For the HPRS support team, this skill is critical across all support levels.
- Ability to cope with stress skills: The HPRS system support queries are not always simple and easy to resolve, some of them become extremely cumbersome and draining. Stress management skills can assist the team to keep calm even in stressful situations, allowing them to think properly and come up with solutions that will solve support queries.

In summary, management skills, people skills, process Ubuntu Linux server basics and technological skills are critical to the HPRS support environment. Ensuring that all support levels have these skills will improve the services rendered to the healthcare facilities and the HPRS system.

14.9 Conclusion

The main key insights of this chapter are obtained from the literature outcomes and are focused on ICT Service Desk Support and the various levels of support query resolution, which includes the support query lifecycle and the phases of addressing support queries. In addition, skill-based sets are examined, including their significance and how they might be improved. These skill-based sets are important because they improve the HPRS support team's skills and support queries while improving the overall HPRS environment. They also align with the digital health workforce, driving strategic economic development intervention that addresses inadequate human resources. This skills-based set will strengthen the workforce for digital technology support and implementation and ensure compliance with the Presidential Health Summit Compact Pillar 9, which measures the need for capacity building and skill transfer in digital health.

Furthermore, recommendations are provided to support the Digital Health Strategy and improve overall health systems. According to Achieng (2021), offering appropriate training and support programs for healthcare practitioners to use Health Information Systems in their professional activities can improve health outcomes, either directly or indirectly. Thus, this chapter's literature

component emphasised mentorship and training to benefit the HPRS support team and the digital health system.

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Chapter 15: Implementation of the Health Patient Registration System in the Free State: Lessons learned

Chikobvu, P.,[1,2] Heunis, J.C.,[3] Setlogelo, M.,[2] Ntombela, B.[4] and Tshilo, T.[3]

[1]Department of Community Health, University of the Free State (UFS); [2]Information Management & Research, Free State Department of Health (FSDoH); [3] Centre for Health Systems Research & Development, UFS; [4]Information, Communication & Technology, FSDoH

Purpose: *The aim of this chapter is to retrospectively describe and analyse the implementation of the HPRS in primary health care (PHC) facilities and hospitals within the Free State Department of Health (FSDoH), while sharing the lessons derived from this process. The chapter seeks to offer insights by detailing the deployment of the HPRS as a component of the modernisation of the Health Information System (HIS) in the Free State Province. It comprehensively addresses the: 1) study approach, 2) implementation process, 3) application of Implementation Science frameworks, 4) results, 5) discusses the benefits and 6) challenges encountered, 7) lessons learned, 8) ethical considerations and human rights issues, and 9) relevance to the NDHS 2019-2024.*

Study design/methodology/approach: *A qualitative approach rooted in Implementation Science was employed to implement the HPRS in the Free State Province. This involved using Participatory Action Research (PAR) and Normalisation Process Theory (NPT) during the implementation. HPRS implementation involved a multidisciplinary team comprising national, provincial, district, subdistrict and facility-level managers and officials with varying roles. The implementation team designed the HPRS implementation plan, which focused on strategic management involvement, tactical integration of the HPRS into healthcare workflows, and operational actions related to user training and involvement. Engagement and consultative meetings were regularly convened at all levels of care to foster buy-in.*

Findings: *As of May 2024, the HPRS had been put into operation across all 221 PHC facilities and 32 hospitals overseen by the FSDoH. This unified patient record system led to enhanced reception services and patient flow. A total of 3,803,980 patients were registered in the HPRS by 7 May 2024, each assigned with a unique HPRN. Furthermore, facility governance structures demonstrated successful leadership in driving the utilisation of the HPRS. Critical success factors for HPRS implementation included buy-in from management and healthcare workers, resource allocation, and continuous monitoring. Challenges encountered encompassed electricity load shedding, fluctuating network connectivity, incidents of computer theft, and, primarily, resistance to change among clinical staff.*

Originality/value: *Implementation of the HPRS in the Free State evidenced that using unique HPRNs improved patient continuity of care and availability of patient historical laboratory results through, amongst others, HPRS-National Health Laboratory Services (NHLS) linkage. Patient movement can now be tracked across the country, and the HPRS has improved data use for planning in PHC facilities. It is argued that successful implementation of the HPRS is key to realising the National Digital Health Strategy, 2019-2024, steering the Province towards a more unified and digitally empowered healthcare ecosystem.*

Keywords: *Health Patient Registration System, Implementation, Participatory Action Research, Normalisation Process Theory*

15.1 Introduction

Table15-1 outlines the key concepts used in this chapter.

Table 15-1: Key Concepts used in this chapter

Digital health refers to "*the use of information and communications technology in support of health and health-related fields*" (World Health Organization, 2019, p. IX).
Health Information System (HIS) denotes "*an information system for processing data, information, and knowledge in health care environments. The goal of a HIS is to use computers and communication equipment to collect, store, process, retrieve, and communicate patient care and administrative information… and to satisfy the functional requirements of all users*" (Jakovljević, 2008, p. 597). It has also been alternatively described as a "*socio-technical subsystem of a health-related setting which comprises all data, information, and knowledge processing as well as the associated human or technical actors in their respective data, information, and knowledge processing roles*" (Winter et al., 2023a, p. 18).
Health Patient Record Number (HPRN) refers to a unique patient identifier "*which allows for identification of the patient and locating the physical position of the patient record within the filing system. The Alpha-Numeric Filing System (ANFS) uses the technology provided by the HPRS to automatically generate the patient record number, thereby linking the unique patient identifier to each patient's record in each facility*" (Wolmarans et al., 2015, p. 39).
Health Patient Registration System (HPRS) is a system developed and set up by the National Department of Health "*to provide Patient Registry and Master Patient Index (MPI) service using the South African Identification Number and all other legal person identification numbers such as Passport as the primary patient identifier*" (NDoH, 2017, p. 73).

Implementation Science has been defined as "*the scientific study of methods to promote the systematic uptake of evidence-based clinical treatments and practices and organisational and management interventions into routine practice*" (Wilson & Kislov, 2022, p. 1).

Master Patient Index (MPI) refers to "*a centralised repository, which indexes all patient records of a given set of information systems. Which is composed of a set of demographic data sufficient to unambiguously identify a person and a list of identifiers that identify the various records that the patient has in the repositories of each information system*" (Jayatissa et al., 2018, p. 37).

Normalisation Process Theory denotes "*a theory which offers trialists a consistent framework that can be used to describe, assess and enhance implementation potential*" (Murray et al., 2010, p. 1).

Participatory Action Research (PAR) represents a research approach that prioritises "*the value of experiential knowledge for tackling problems caused by unequal and harmful social systems and for envisioning and implementing alternatives*" (Cornish et al., 2023, p. 1).

According to the World Health Organization (WHO, 2020), while Health Information Systems (HISs) play a vital role in identifying access and quality of care issues that prevent the attainment of universal health coverage (UHC), no country in the world has a fully mature HIS capable of meeting its evolving needs for health information.

The deployment of health information technology can help increase the value of healthcare delivery (Weigel et al., 2015), improve patient safety (Sittig et al., 2020), reduce medical errors (El-Kareh et al., 2013), and strengthen healthcare provider-to-patient engagement (Graffigna et al., 2013). Utilising health information technology to develop efficient HISs is vital for improving healthcare delivery worldwide (Popescu et al., 2022; Hotchkiss et al., 2012; Lal et al., 2022). HISs play a pivotal role in healthcare organisations by facilitating the integration of health-related processes and information systems within the healthcare sector (Epizitone et al., 2023). An HIS can streamline management and operational processes by supplying vital information and promoting cohesion among technology, staff, and procedures. This aligns with ongoing modernisation efforts within the health system, fostering improved access to high-quality healthcare services and driving down operational costs. A significant advantage of HISs is their capacity to promptly generate patient health information, thereby enhancing healthcare continuity through improved care coordination facilitated by health information exchanges among all healthcare providers and managers across various levels. Nevertheless, the financial investment necessary for implementing HISs presents a considerable challenge for healthcare systems, especially in developing nations (Koumamba et al., 2021).

Furthermore, while HISs enhance healthcare delivery, a significant hurdle lies in health establishments' vast array of disparate information systems. HISs often lack integration and fail to facilitate cohesive patient care across all tiers of the healthcare system (Haule & Muhanga, 2021). Advocates for healthcare reform argue that patient registration establishes an accountability framework essential for attaining elevated levels of health system continuity and coordination (Marchildon et al., 2021, p. 1508). Patient registration with a primary care provider aligns with broader health system reforms, particularly those emphasising improved continuity of care for all.

In the National Digital Health Strategy for 2019-2024 (NDHS 2019-2024), the South African National Department of Health (NDoH, 2019) emphasises enduring strategic challenges in digital health, particularly regarding fragmented and poorly coordinated systems. The Health Patient Registration System (HPRS) Project was launched as a crucial preliminary step towards establishing a patient electronic health record, aligning with the mandate for patient registration outlined in the Green Paper on National Health Insurance (NHI) dated August 12, 2011 (NDoH, 2011). Adopting the HPRS not only aids in identifying individuals eligible for NHI benefits but also empowers the NDoH in the strategic planning and provisioning of healthcare facilities and services (NDoH, 2015). In 2019, the final evaluation of Phase 1 of the interventions in the NHI pilot districts reported that the HPRS, "which has the ultimate goal of a fully electronic patient record-keeping system," had commenced with the capturing of patient data and the generation of electronic files (Genesis Analytics, 2019, p. 11). The HPRS has since emerged as a significant initiative to enhance patient management and healthcare service provision. It represents a pivotal initiative in South Africa's healthcare landscape, aiming to streamline patient management and improve healthcare delivery, including broader digital health initiatives. The NDoH hosts the HPRS data. A robust data hosting infrastructure was established, and system maintenance and update protocols were implemented to ensure data security and system reliability. The implementation of the HPRS holds great promise in improving healthcare delivery in South Africa. It represents a powerful digital transformation in health care, enabling electronic patient registration, data sharing, and enhanced care coordination.

Therefore, this chapter aims to retrospectively describe and analyse the implementation of the HPRS in primary health care (PHC) facilities and hospitals within the Free State Department of Health (FSDoH) while sharing the lessons derived from this process. The chapter seeks to offer insights by detailing the deployment of the HPRS as a component of modernising the HIS in the Free State Province. It comprehensively addresses the: 1) study approach, 2) implementation process, 3) application of Implementation Science frameworks, 4) results, 5) discusses the benefits and 6) challenges encountered, 7) lessons learned, 8) ethical considerations and human rights issues, and 9) relevance to the NDHS 2019-2024.

15.2 Study Approach

A qualitative approach rooted in Implementation Science was employed during the implementation of the HPRS in the Free State Province. This involved using Participatory Action Research (PAR) alongside constructs and methodologies from Normalisation Process Theory (NPT). Participatory action research can be defined as a collaborative process in which community members and researchers work together to investigate issues and develop solutions that directly address the needs and interests of the community (Whyte, 2008). This approach emphasizes the direct involvement of those affected by the research, in contrast to traditional academic research that is often conducted in isolation from the communities being studied (Vaughn & Jacquez, 2020).

At the heart of participatory action research is a commitment to social justice and democratic principles. Researchers work in partnership with their colleagues, drawing on their knowledge and expertise to shape the research questions, data collection and analysis, and the implementation of findings. This inclusive approach aims to reduce the power imbalances that often characterize traditional research models and to ensure that the research process and outcomes are relevant and beneficial to everyone involved (Vaughn & Jacquez, 2020). Normalisation Process Theory (NPT) is a framework for understanding how new practices are implemented, embedded, and sustained in healthcare and other organizational contexts (Benjamin-Thomas et al., 2018). The key elements of participatory research - collaboration, education, and action - resonate with the core tenets of Normalisation Process Theory, which emphasizes the collective work undertaken by people and groups to make a new practice function in everyday life (Macaulay et al., 1999).

The aim was to ensure the effective implementation of the HPRS by engaging stakeholders and comprehensively understanding the contextual factors.

15.3 The Implementation Process

This section describes the following: 1) the Implementation Team; 2) the training of officials; 3) changes made to the Patient Administration System (Patient Administration System); 4) change management; and 5) governance and oversight during the implementation process.

15.3.1 The Implementation Team

The Implementation Team consisted of officials from the NDoH, national supporting partners, provincial, district, subdistrict, facility teams, and district supporting partners, all with specific roles (Table 15-2).

Table 15-2: The implementation team

Level	Designation	Role
National	Chief Information Director and Team.	Engagement meetings for buy-in from the Province. Facility readiness assessment. Provision of required assets. Training of provincial team.
	Supporting Partner (HISP).	Facility readiness assessment. Training of provincial team. Distribution of assets (computers, routers, tablets, and laptops).
Provincial	Senior Managers for ICT. .Management and Teams. Clinical Cluster Representative. Asset Manager.	HPRS implementation coordination. Facility readiness assessment. Engagement meetings with district management teams. Setting up the computers and scanners at facilities. On-site face-to-face practical training.
District	PHC Manager. LAM. DIO. M&E Manager. Subdistrict Clerks. Supporting Partners. Asset Manager. Infrastructure Manage.r ICT Support Team.	Setting up the computers and scanners at facilities. Reorganise the Patient Administration System area. Conducting on-site, face-to-face practical training. Providing continuous technical support to the facility as needed.
Facility	Operational Manager. Administration Clerks. Professional Nurses.	Communicating the need for IDs to access healthcare services. Educating patients regarding the HPRS. Educating clinic committee members on the need for IDs to access healthcare services. Participating in reorganising the Patient Administration System. Capturing patients' information on the HPRS. Using dashboards for planning resource allocation and leave allocation to staff. Tracking *lost-to-follow-up* cases. Using the HPRN to access patients' NHLS laboratory results. Using the HPRN to pre-pack medicine for booked patients.
	Supporting Partners.	Supporting the facility with the implementation of the HPRS.

Abbreviations*: DIO: District Information Officer; HISP: Health Information System Programme; HPRN: Health Patient Registration Number; HPRS: Health Patient Registration System; ICT: Information, Communication and Technology; ID: Identity Document; LAM: Local Area Manager; M&E: Monitoring and Information; NHLS: National Health Laboratory Service; PAS: Patient Administration System; PHC: Primary Health Care*

15.3.2 Training of Officials

To support the successful implementation of a digital health initiative such as the HPRS, the NDHS 2019-2024 recognises the need for a skilled digital health workforce (NDoH, 2019, p. 25). This involves developing training and capacity-building programmes to equip healthcare professionals with the technical skills to effectively manage and use digital health systems (Khoja et al. 2012). In the Free State, continuous training and capacity building were pivotal in providing sustained

support to facility personnel and managers at different levels of care, especially with the introduction of the HPRS. This necessitated the engagement of various stakeholders across the facility, subdistrict, district, and provincial levels to ensure consistent support for the comprehensive implementation of the HPRS.

The NDoH team trained the provincial master trainers. The FSDoH and NDoH teams developed a facility-specific training plan to train the end-users. A comprehensive on-site training programme was conducted to equip healthcare professionals with Patient Administration System and HPRS functionality, ensuring smooth adoption and utilisation. This entailed on-site face-to-face training on migrating from the *Brown File* (paper file with clinical stationary pages placed inside) to the new patient booklet, including the appointment system. A video on implementing HPRS in a PHC setting was developed and used as an electronic training platform for facilities to refer to when unsure of implementing any modules in the HPRS.

Facilities were signed off once the training team was satisfied that the facility officials could continue implementing the HPRS independently. Once the facility was signed off, the training team moved to the next facility, where readiness assessment and consultative meetings were conducted. Tailored implementation plans were collaboratively developed with the facility staff at each facility. Facility optimisations were conducted, and routers and computers were set up accordingly. This was followed by comprehensive on-site, face-to-face, practical training. The training of administrative staff, including clerks, progressed relatively smoothly. However, significant resistance arose among clinical staff, particularly nurses, regarding the general use of computers and the HPRS dashboard specifically.

15.3.3 Changes to the Patient Administration System

In recognising the importance of a well-organised Patient Administration System as the foundation for ensuring smooth patient access to healthcare facilities, it becomes clear that integrating registers within these facilities is indispensable (Wolmarans et al., 2015). This consolidation serves as the bedrock for optimising HISs, enhancing facility management, and ultimately elevating the patient experience. A cohesive Patient Administration System is the first step to ensure a rationalised process of patient access to healthcare facilities that, in turn, supports quality health information services and effective facility management while improving the patient experience. Five elements were identified as key to its iterative development: 1) the optimisation of facility business processes (e.g., reorganising the patient workflows); 2) the rationalisation of registers (rationalised set of six registers for collection of routine health programme data as of the 2015/16 financial year); 3) providing a standardised facility-held patient record (booklet); 4) the standardisation of the accompanying filing system; and 5) the development of the HPRS (Figure 15-1).

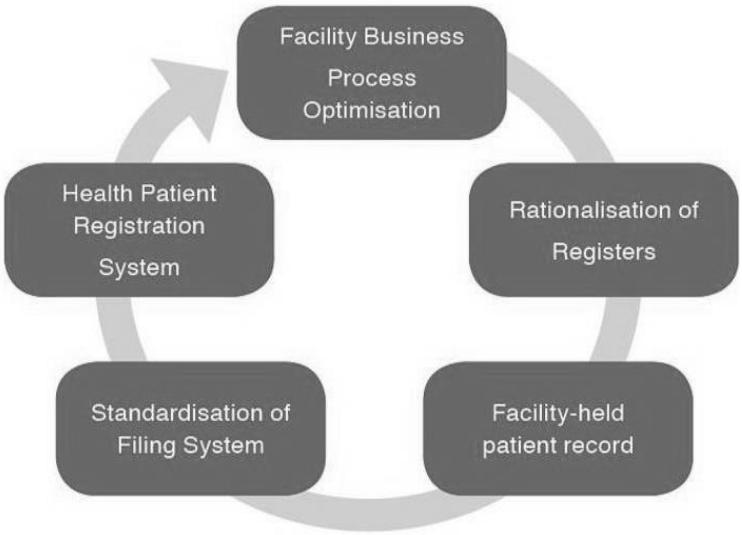

Figure 15-1: Key Elements of the Patient Administration System (Wolmarans et al., 2015)

The optimisation of facility business processes included, firstly, reorganised patient flow, indicating that specific activities involving patient care take place in designated areas; and, secondly, re-designed reception services, which include activities such as patient registration, patient record retrieval, filing of patient records, the patient appointment system, and the recording of the daily headcount. All these activities occur at the reception as one business process (Wolmarans et al., 2015). This process is crucial as it involves proper workflows at the reception. The Patient Administration System implementation was piloted at the NHI sites in Thabo Mofutsanyana District, demonstrating its feasibility and effectiveness in enhancing healthcare service delivery.

Following the implementation of the Patient Administration System at the facility, patients must have their identification documents (IDs) with them when they visit the facility. Upon arrival at the reception waiting area, they must provide their IDs to be able to register in the HPRS. The patient file is retrieved if it is not pre-retrieved (for booked patients). The patient then joins the service stream related to their visit. The administration clerk takes the patient file to the relevant consulting room. After consulting with a professional nurse, the patient returns to the reception area to schedule an appointment as instructed by the nurse.

Implementation of the HPRS enabled the clinics to create a standardised filing system using the HPRN and a well-defined appointment system aligned across all critical policy initiatives such as the Ideal Clinic Framework (NDoH, 2022) and the Integrated Clinical Services Management (ICSM) Guideline (NDoH, n.d.). Implementing the standardised patient record (booklets for female, male and child patients, respectively) aligns with the *One Patient, One File* strategy to reduce the number of files and duplications. According to the United Nations Development Programme (UNDP, 2024), this strategy aims to "*leverage state-of-the-art technology, facilitating*

a shift to a more cost-efficient, patient-centric, and accountable system for managing patient records, details, and test results."

15.3.4 Change Management

Change management initiatives focused on transitioning from a paper-based to a digital HPRS business process. Previously, patient identification relied on birth dates, whereas the unique HPRN would forthwith be used. Change management was incorporated in the consultative meetings and indirectly embedded in the implementation process. At the facility level, change management was introduced through face-to-face practical processes. The facility officials were the agents of change themselves as they sought to reduce the excessive amount of paperwork, including many registers and loose papers in the *Brown File*. The HPRS ecosystem underwent a transformed, adopting the *One Patient, One File* system using booklets, organising file cabinets based on the HPRN, implementing an appointment system with pre-retrieval of files, and establishing a single entrance and exit point for patients.

Implementing this ecosystem decreased patient queues, enhanced staff morale, and reduced the workload of professional nurses. Tailored, face-to-face training and ongoing support played pivotal roles in effectively managing organisational change, particularly at the facility level. This entailed actively involving facility healthcare workers (HCWs) and other stakeholders throughout the process, addressing potential resistance to change, and facilitating the adoption and integration of the HPRS into routine Patient Administration System procedures. Furthermore, incorporating user feedback and needs, alongside collaboration with the supporting partners, significantly improved user satisfaction and optimised system utilisation.

15.3.5 Governance and Oversight

The NDHS 2019-2024 underscores the significance of implementing robust governance and oversight mechanisms (NDoH, 2019, p. 11). These mechanisms are crucial for ensuring accountability and efficient management of digital health resources, pivotal for the successful adoption and longevity of systems such as the HPRS.

The indispensable governance role of clinic committees was evidenced during the implementation of the HPRS in the Free State. The Implementation Team's consultation with the clinic committees' chairpersons at the beginning of HPRS implementation and their regular engagement throughout the process played a vital role in securing community and patient buy-in in the new Patient Administration System procedures they would encounter when accessing PHC facilities. These engagements, supplemented by videos, illustrated how the HPRS implementation would benefit the community, particularly by minimising waiting times.

In cases of theft of facility computers, reports were submitted to the Risk Committee, which collaborated with the Provincial Security Directorate, district, subdistrict and operational managers

and clinic committee chairpersons to devise strategies to prevent such incidents. The clinic committees are vital in communicating to the community that resources such as computers are dedicated to serving them effectively. Consequently, they are implored to remain vigilant in preventing theft and break-ins that compromise public goods within (their) facilities.

Functional governance structures at the facility, sub-district, district, provincial, and national levels are critical to driving the use of the HPRN. Community structures, particularly the clinic committees and hospital boards, are key to service delivery. These structures are designed to enable and support clinicians to provide the best possible healthcare service. Coordination at the facility level was crucial for entrenching the use of HPRN. The facility operational manager responsible for implementing the HPRS ensured that the HPRS implementation was discussed during the clinic committee meetings to obtain the buy-in from community members. The clinic committee chairperson would then share the implementation of the HPRS during the ward committee meetings, where information on the benefits of the system would be shared with the community at large. Clinics conducted daily health talks on the use and benefits of the HPRS, the appointment system, as well as the pre-packing of medication.

At the hospital level, the hospital board meetings were used to introduce the HPRS system and obtain patient buy-in. The hospital boards used their community meeting platforms to share the information. The hospitals usually hold annual Open Day events where hospital services or any other new programme/projects are displayed and explained to the community members.

15.4 Application of Implementation Science Frameworks

Implementation Science entails increased use of theoretical approaches to better understand and explain how and why implementation succeeds or fails (Nilsen, 2015). Implementation Science has long been advocated as fundamental for effectively deploying an HIS (Hynes et al., 2013). This entails analysing the unique context of healthcare and health information technology settings, pinpointing barriers and facilitators, crafting customised adoption strategies, prioritising continuous evaluation and feedback, and ensuring sustainable long-term practices. Through applying these principles, healthcare organisations can bolster the adoption and seamless integration of HIS, ultimately fostering enhanced patient care and outcomes. These principles were applied during the implementation of the HPRS in the Free State, as described in Section 15.3.

15.4.1 Participatory Action Research

Participatory action research (PAR) is often considered a method within Implementation Science (Markey et al., 2023; Ramanadhan et al., 2023; Harvey & Kitson, 2016). PAR plays a vital role in implementing decolonised research practices (Omodan & Dastile, 2023). Incorporating the active involvement and leadership of individuals directly impacted by the issues at hand, PAR diverges significantly from traditional research approaches by placing a central emphasis on collaborative inquiry Cornish et al., 2023). When executed effectively, PAR ensures transparency in its

objectives. Therefore, PAR practitioners often opt for techniques and instruments that enable inclusive, democratic involvement, prioritising authentic and significant engagement.

In the current study, from 2016 onward, a PAR approach was adopted, leveraging qualitative Implementation Science methods to introduce the HPRS across the Free State Province effectively. Following the framework outlined by Cornish et al. (2023), the project design embraced key elements, including 1) fostering relationships, 2) establishing effective working practices, 3) cultivating a shared understanding of the issue, 4) collecting, observing, and generating pertinent materials, 5) engaging in collaborative analysis, and 6) strategising and implementing action plans. Furthermore, the NPT was applied to enhance collective accountability and involvement and streamline the integration of the HPRS into routine Patient Administration System (PAS) processes. A multidisciplinary team analysed the HPRS Implementation Plan and rollout, focusing on 1) management involvement (strategic actions), 2) integration of the HPRS in healthcare workflows (tactical actions), and 3) user involvement, education, and training (operational actions) (Epizitone et al., 2023; Masrom & Rahimly, 2015; Winter et al., 2023b). Engagement and consultative meetings were held at each level of care to facilitate buy-in. Assessments were conducted to identify facilities' needs. Facility-specific HPRS on-site face-to-face training and implementation were initiated based on the readiness reports.

The PAR approach meant end-users actively participated in developing facility-specific implementation plans. The collaborative approach thus involved end-users of health patient registration during the implementation, ensuring that HPRS implementation occurred effectively. This methodology engaged healthcare professionals, administrators, and patients to create a user-centred, context-relevant implementation process. The participatory design and methodology involved stakeholders from healthcare facilities, Information and Communication Technology (ICT) personnel, policymakers, district supporting partners, and clinic committees representing patients and communities.

Successful implementation relied on the active involvement of stakeholders throughout the process. This included individuals and groups affected by the intervention, including those responsible for implementing and sustaining it. Engaging stakeholders helps build buy-in, identify barriers and facilitators, and promote intervention ownership (Eisman et al., 2012). The implementation process in the Free State Province entailed the following PAR steps:

1. Consultative meeting conducted: Participatory implementation consultations and implementation sessions with the provincial HoD and senior managers to inform and brainstorm ideas regarding the implementation of the HPRS were conducted first by the NDoH.
2. Follow-up consultative meeting: The follow-up participatory meeting workshop on the HPRS implementation regarding the Patient Administration System process (theoretical reorganisation of administration workflows as well as understanding the

basic implementation requirements) was conducted by NDoH in collaboration with operational teams from the Province and districts.

3. Formation of Implementation Teams: Multidisciplinary national, provincial, and district Implementation Teams comprised of representatives from different stakeholder groups ensured that diverse perspectives and expertise were constituted. Each district provided an Implementation Team to work with the national and provincial teams.
4. Stakeholder identification: Each district identified facility-specific key stakeholders involved in implementing patient administration, including healthcare professionals (doctors and nurses), administrators, ICT personnel, policymakers (district management teams), district supporting partners and patients.
5. Selection of pilot site: Seven facilities from the NHI District (Thabo Mofutsanyana) were selected to pilot the implementation process and evaluate the adoption and integration of the HPRS in the facilities' routine patient administration process. The pilot started in September 2014.
6. Contextual assessment: The national, provincial and district teams conducted facility-specific site visits and readiness assessments to understand the workflows, challenges, and requirements of end-users concerning patient registration and data management. During the site visits, all the facility staff were informed about the HPRS's functionality and purpose by the NDoH team.
7. Readiness assessment feedback: The facility and district management teams received feedback from consultative workshops, incorporating usability principles and best practices in facility implementation plans.
8. Distribution of assets: The NDoH provided computers and routers with data to the selected facilities based on the outcome of the readiness assessments. To ensure equitable access to the HPRS, some facilities without connectivity or routers used 3G cards to access the HPRS. Even though facilities were affected by load shedding, consistent back-capturing of information on the HPRS was encouraged to maintain accurate and up-to-date information to support quality care delivery.
9. End-user training: On-site face-to-face training was conducted for all the facilities. The facility was signed off once the training team was satisfied that the facility officials could implement the HPRS on their own. Once the facility was signed off, the training team moved to the next facility, where readiness assessments were done before following points 7-9 above.
10. Monitoring and Evaluation (M&E): Continuous M&E of HPRS usage was conducted at all levels of care by the Implementation Teams in the pilot sites.
11. HPRS usage feedback: Facility-specific HPRS usage feedback was provided to the

facility, subdistrict, and district managers, incorporating the users' feedback on the implementation process considering the HPRS's usability, functionality, and impact on workflows provided through qualitative interviews with the users at the facility as well as the facility's technical support team.

12. Cascading HPRS implementation: Implementation of the HPRS was cascaded to all the PHC facilities in Thabo Mofutsanyana following the process established during the pilot process. After completing all the facilities in Thabo Mofutsanyana, the next district was selected, and the process started again. HPRS implementation was thus done following district and facility-specific processes.
13. Continuous implementation improvement: The feedback and insights gathered from the pilot implementation sites were used to refine the implementation process and involve other sections of healthcare facilities using unique HPRNs to align with the evolving needs of end-users and the healthcare system.
14. Use of unique HPRNs: Facility-specific reorientation was conducted to include using the unique HPRNs during the implementation process and to demonstrate how the HPRN links with the pharmacy section to address process-flow issues and improve user experience. This included using an appointment system, which allowed for pre-retrieval of patient files.
15. HPRS-NHLS linkage: Professional nurses in the consulting rooms were trained to use the HPRN to access the patient results from the NHLS before they conducted any tests in case the needed results were already available. This improved continuity of care and reduced laboratory costs.
16. Patient tracking: Facilities underwent training to use the distinctive HPRN system, enabling tracking patients who might have been categorised as *lost-to follow-up* in one facility but were seeking services elsewhere.

15.4.2 Normalisation Process Theory (NPT)

The NPT is a commonly used implementation theory and framework to facilitate understanding the extent to which new processes become part of routine practice (Wilson & Kislov, 2022, p. 16). The Health Information System Programme (HISP), in collaboration with the NDoH, conducted the HPRS implementation buy-in engagements through consultative meetings with the provincial leadership and district management teams. The NDoH team and FSDoH officials jointly conducted the readiness assessments for seven selected facilities, starting with the NHI district, Thabo Mofutsanyana. Based on the NPT, participatory discussions and workshops were held with healthcare managers, HCWs, clinic committees, district supporting partners, and local stakeholders to obtain their buy-in for implementing the HRS in Thabo Mofutsanyana's seven PHC facilities. The NPT was adopted to guide the development of the HPRS Implementation Plan that supports the integration of the HPRS into routine health care (Ross et al., 2018; May et al.,

2018; May et al., 2009). The four main components of the NPT, namely *coherence*, *cognitive participation*, *collective action*, and *reflexive monitoring*, were considered in implementing the HPRS. Normalisation was facilitated by actively involving health and operational managers, administrative clerks, and frontline HCWs to understand and facilitate the implementation of the HPRS into the routine Patient Administration System at the facility.

It was hypothesised that the facility's operational managers and facility HCWs would lead the implementation of the HPRS, demonstrating that they understood the purpose of the HPRS (coherence), would be prepared to invest time and energy into its implementation (cognitive participation), would feel that the HPRS integrates well into optimisation of workflows (collective action), and would perceive the HPRS to be worthwhile (reflexive monitoring). As shown in Table 15-3, the operationalisation of these constructs and strategies targeted the implementation of the HPRS within the Implementation Plan.

Table 15-3: HPRS Implementation Plan – NPT Constructs, Strategies and Operationalisation

Construct	Strategy	Operationalisation
Coherence	Informing and consulting senior managers and local opinion leaders.	Key people within FSDoH identified at the convened NDoH meeting Senior managers, district managers, DIOs, sub-district clerks, LAMs, operational managers, and clinic committee members were informed about the HPRS and the need to develop an action plan to implement changes Asset (computers, routers, manuals and framework documents) were distributed to facilities by NDoH.
	Communication workshops and meetings.	Buy-in meetings were organised with all key officials identified above Required changes were discussed and the opinions of attendees documented Posters explaining the expected changes were developed and distributed to all stakeholders and facilities Responsibility to incorporate and communicate changes were assigned to DIOs and LAMs Pamphlets with contact numbers for the ICT support team were provided to each facility.
	Stakeholder engagement through buy-in meetings and workshops.	Meetings were arranged between senior management of FSDoH and key stakeholders in each district, including the district management teams The NDoH team provided information and discussed the impending changes required.
Cognitive participation	Clinic committee education.	Clinic committee members took part in information-sharing sessions, which provided an opportunity for them to understand actions expected from staff to sustain the implementation of the HPSR in practice.
	Local consensus processes.	Consultations with groups of senior managers, HCWs, clinic committee members and supporting partners allowed the opportunity to discuss and decide how the work of HPRS implementation (including the use of IDs to access services) would be shared within the facility and how changes would be monitored.
	Implementers to champion reconfiguration of the Patient Administration System areas.	Implementers (all relevant FSDoH leaders, supporting partners and clinic committee members) were involved starting from the pilot readiness assessment phase through the development and execution of the Implementation Plan.
Collective action	Review of Patient Administration System and role clarification.	Workshops were held with facility and district teams to explain reporting lines for technical support and logging of calls

Construct	Strategy	Operationalisation
	Streamlining of patient flow and introduction of streams of care according to the ideal clinic and ideal hospital frameworks.	Enabling policies and reporting, oversight and feedback mechanisms put in place.
Reflexive monitoring	Revival and strengthening of governance structures (clinic committees) with administrative support.	As stated, meetings were convened with clinic committee members to establish their role in the HPRS implementation process and the use of IDs to access healthcare services Regular orientation and reflection sessions were held on how to support the HPRS implementation process.

Abbreviations*: DIO: District Information Officer; FSDoH: Free State Department of Health; HCW: Healthcare Worker; HPRS: Health Patient Registration System; ID: Identity Document; LAM: Local Area Manager; NDoH: National Department of Health; NPT: Normalisation Process Theory; PAS: Patient Administration System*

The NPT allowed for the consideration of the barriers and facilitators identified during the readiness assessment and the selection of appropriate implementation strategies. As applied and recommended by May et al. (2009), the NPT brings practice to action, including embedding HPRS usage into the everyday patient registration process. The selection of change strategies was based on the Cochrane Effective Practice and Organisation of Care (EPOC) taxonomy of implementation strategies (EPOC, 2016). The HPRS was designed to change the facility Patient Administration System, aiming to integrate the HPRS into the service delivery process and improve service delivery performance.

Meetings with the provincial HoD, senior, district and subdistrict, facility and operational managers of the FSDoH were convened by the NDoH to develop a strategy to implement the Patient Administration System changes in the PHC facilities. Individual implementation strategies were selected, and a generic implementation plan was developed. Following readiness assessments, facility-specific implementation plans were developed on-site. The delivery of the change mechanism included various actions to enhance integration and improve the outcomes of the Patient Administration System, registration, and service delivery embedded in the facility-specific implementation plans. Regarding service delivery, the one-stop service-rendering plan and streams of care had to be strengthened based on the Ideal Clinic Framework (NDoH, 2022) and the Ideal Hospital Framework (NDoH, 2023). The services were reorganised accordingly to enable PHC facilities to offer comprehensive packages of PHC services (Heunis et al., 2006) linked to HPRS implementation. The Patient Administration System was reorganised and reviewed to integrate the HPRS into the patient administration process. New and reviewed interlinked ecosystem procedures were implemented, and change management processes were collaboratively put in place to obtain buy-in from all levels of personnel, managers and community members through clinic committees and other stakeholders. Facility-specific managers were

assigned responsibilities to function as change agents (champions) within their functional lines and foster integrative functioning of the HPRS in their respective facilities.

A facility-specific phased-in approach was adopted to test the HPRS Implementation Plan and refine it on a small scale. Thus, HPRS implementation was incrementally evaluated on a facility-by-facility basis, and refinements were made accordingly before facility sign-off. This cautious approach resonates with the view of Wight et al. (2016) that since repeated testing, monitoring and evaluation is required, large-scale integration of services and policy changes are difficult to pilot for a huge public health service. This is especially the case where the intervention is a novel idea that has not been implemented elsewhere. The HPRS Implementation Plan was thus informed by the literature review, theory of implementation and the use of the information collected during the consultative meetings and workshops with the provincial departmental leadership and the operational teams. The implementation strategies were selected in line with the constructs of the NPT and subsequently increased the likelihood of implementation.

15.5 Results

The provincial and district teams continue to provide technical and general support to the facilities and continuously monitor the facilities' usage of the HPRS. User access to the HPRS created by the NDoH is facilitated by the facility supported by the Provincial Office. The holistic usage of the HPRS in the Free State and a comparison of preliminary data on implementation and usage across the nine provinces and patient satisfaction are presented next.

15.5.1 Holistic HPRS Usage During Healthcare Service Delivery

Figure 15-2 demonstrates the comprehensive integration of the HPRS within Free State healthcare facilities post-full-scale implementation. The HPRN assumes a multifaceted role, encompassing crucial tasks such as file management, anticipatory retrieval of patient records for scheduled appointments, medication pre-packaging, and retrieval of patient laboratory results from the NHLS. Moreover, the HPRN plays a pivotal role in monitoring patients who are previously designated as *lost-to-follow-up* but are accessing services from another facility.

The patient's journey commences at the reception desk, where the administration clerk verifies the patient's registration status. If the patient is already registered, their visit is promptly recorded. Subsequently, upon retrieval of the patient's file, the individual is guided to the consulting room, with the administration clerk facilitating the transfer of the patient's file to this area. When the patient is not yet registered in the HPRS, the administration clerk undertakes the registration process. This entails printing stickers, establishing a patient file, and assigning an HPRN to the respective file.

Inside the consulting room, the professional nurse assumes responsibility for patient care, leveraging their NHLS user access credentials to retrieve patient results from the NHLS, utilising

the patient's HPRN as a reference. Following consultation, the patient proceeds to the pharmacy for medication collection. Upon completion of the consultation and medication procurement, the patient returns to the reception area, where the administration clerk facilitates scheduling the next appointment. Finally, the patient exits the healthcare facility, as depicted in Figure 15-2.

The patient arrives at the reception, and the administration clerk checks whether the patient is already registered; if yes, the patient visit is registered. After the patient file has been retrieved, the patient is directed to the consulting room, and the administration clerk takes the patient file to the consulting room. If the patient has never been registered on the HPRS before, the administration clerk will register the patient, print the stickers, open the patient file, and write the HPRN on the patient file. The professional nurse continues to assist the patient in the consulting room by checking for patient results from the NHLS using the professional nurse's NHLS user access credentials and the patient's HPRN. After consultation with the professional nurse, the patient collects the medicine from the pharmacy and returns to the reception, where the administration clerk schedules the next appointment. The patient then exits the facility (Figure 15-2).

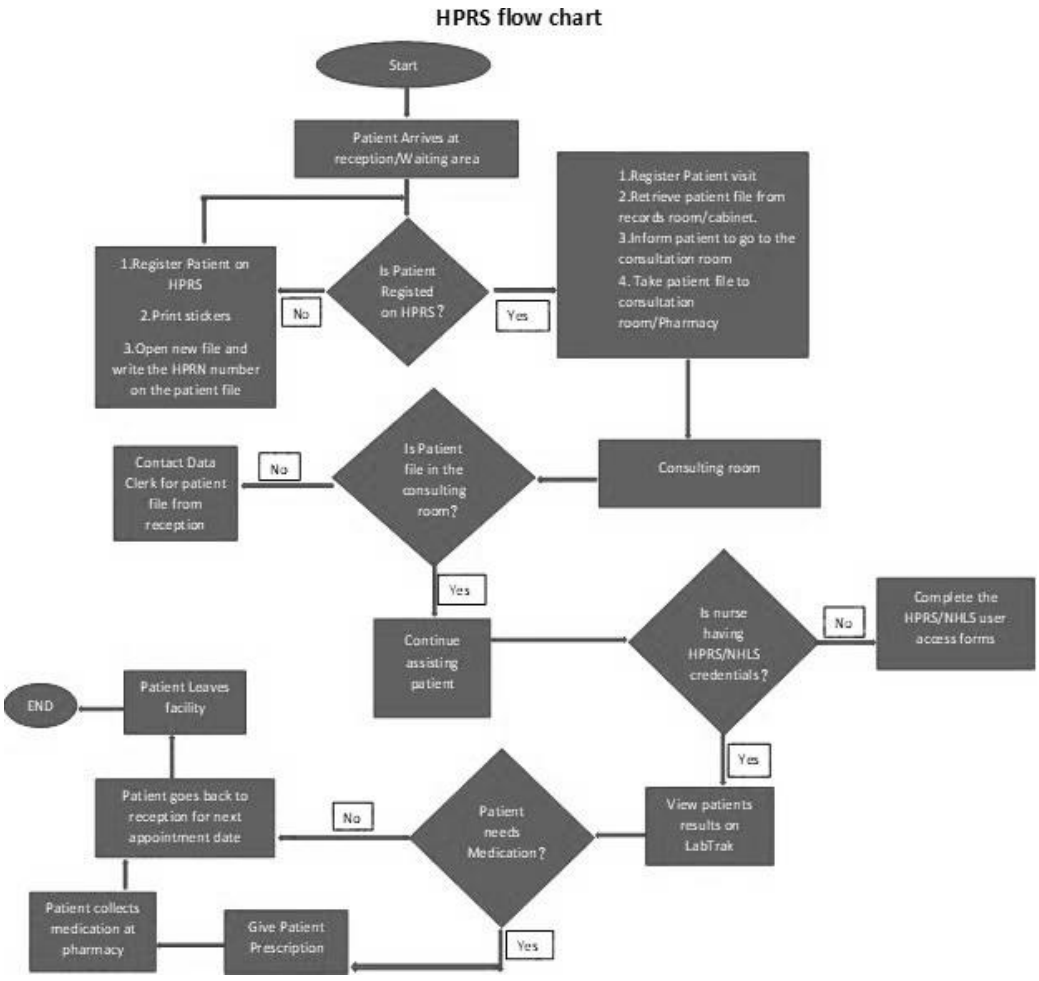

Figure 15-2: Flowchart of Holistic HPRS Usage During Healthcare Service Delivery

15.5.2 HPRS Usage Change, 2016-2023

This section examines the utilisation patterns of the HPRS in the Free State Province from 2016 to 2023. Notably, there was a consistent upward trend in patient registrations from 2016 to 2018, peaking in the latter year (see Figure15-3). The surge in registrations during this period can be attributed to the FSDoH's gradual expansion of the implementation of the HPRS beyond the Thabo Mofutsanyane District. The increase in registrations is also due to the pilot implementation of the HPRS in hospitals in 2018, initially covering six hospitals, including the prominent Pelonomi and Universitas hospitals. Subsequently, the decline in registrations from 2019 onwards signifies a saturation point, indicating that a substantial portion of the population had already been enrolled in the system. This is evident when considering the cumulative registrations over the preceding three years, which surpassed the two million mark. The dwindling rate of new registrations from 2019 onwards can also be attributed to the progressive enrollment of the remaining population cohort. The onset of the COVID-19 pandemic in 2020 further impacted healthcare utilisation patterns, reducing facility visits. However, it is noteworthy that the anticipated influx of new registrations during this period remained subdued compared to previous years.

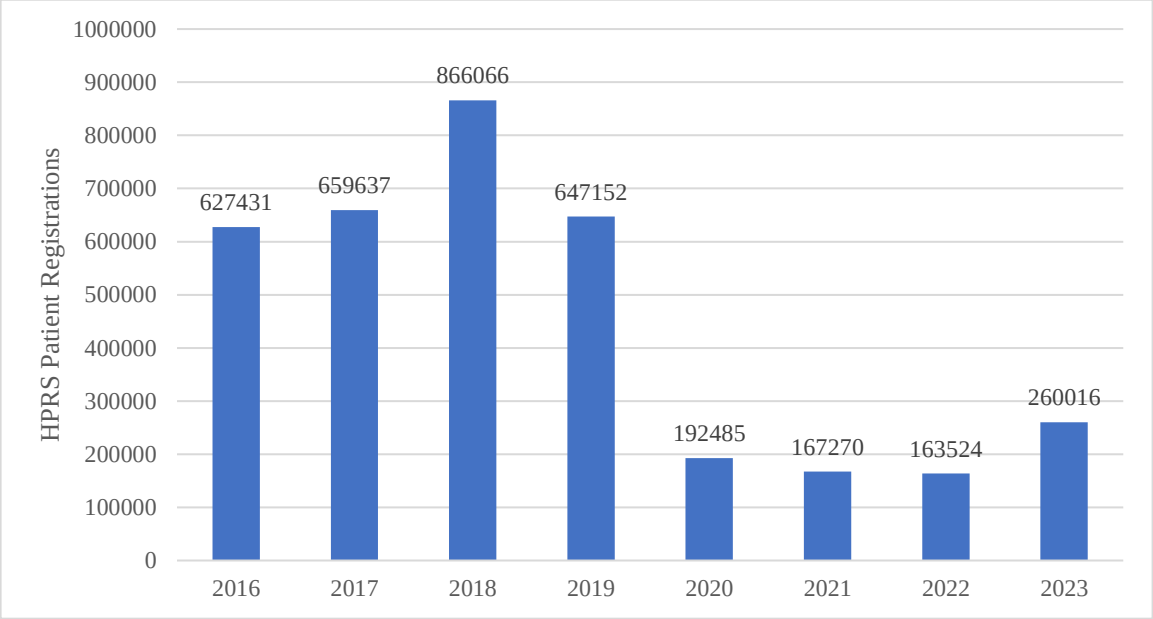

Figure 15-3: Free State HPRS Patient Registrations, 2016-2023 (NDoH, 2024).

Figure 15-4 illustrates the recorded number of patient visits in the HPRS from 2016 to 2023. Registrations showed an upward trend from 2016 to 2018, followed by a decline from 2019 to 2021 and then a subsequent increase. This indicates active patient engagement with healthcare facilities utilising the HPRS for visit documentation. The decrease in registrations between 2019 and 2021 could be attributed to the impact of COVID-19.

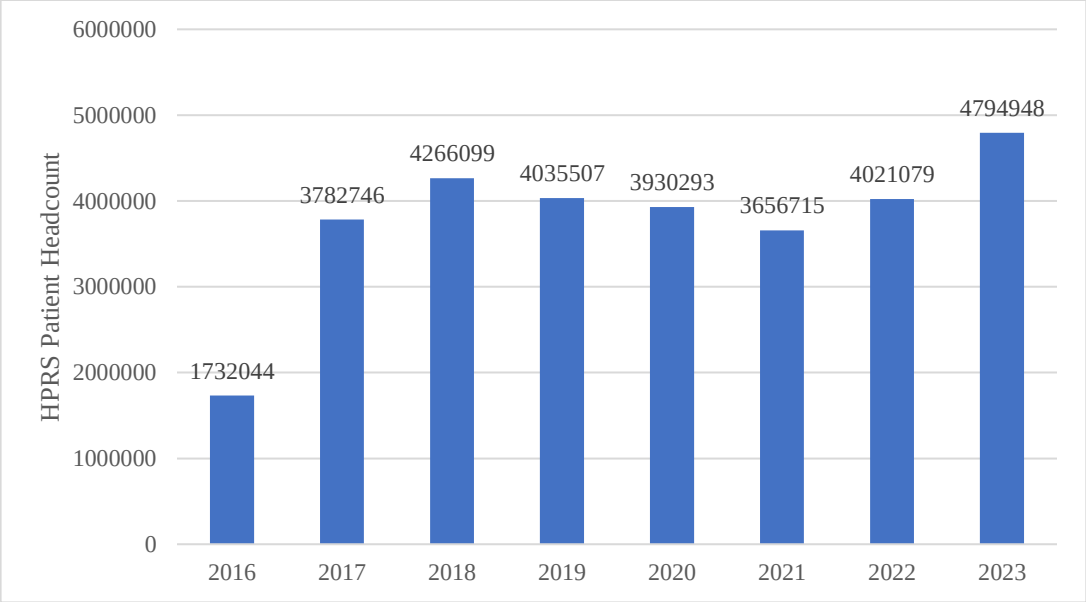

Figure 15-4: Number of patient visits recorded, 2016-2023 (NDoH, 2024)

15.5.3 Provincial Comparison of HPRS Implementation in PHC Facilities

In order to illustrate the deployment and utilisation of the HPRS across South Africa's nine provinces, preliminary PHC data was sourced from the NDoH's central database (2024). Table 15-4 presents a comparative analysis of HPRS implementation and usage within PHC facilities across the provinces. Also, Table 15:4 delineates the total count of registered PHC facilities on the HPRS and the proportion actively utilising the system for each Province. Additionally, it provides insights into the number of registered patients, reported visits, and provincial populations (Statistics South Africa, 2022).

Six provinces initiated HPRS testing/implementation in 2014, while two provinces commenced in 2019; notably, one Province has yet to initiate implementation. Among the eight provinces engaged, seven have surpassed an 80% registration rate of their respective populations, except Gauteng Province, which currently stands at 52.2%. Notably, several provinces exhibit registration rates exceeding 100%, suggesting the inclusion of non-residents and/or foreign nationals (e.g., individuals from Lesotho seeking healthcare services in the Free State). Concerns arise regarding duplicated patient records, particularly when facilities fail to synchronise promptly with the central database. This leads to patients seeking care across multiple facilities or provinces before synchronisation occurs. This underscores the imperative to thoroughly clean and process the preliminary data. The onset of the COVID-19 pandemic prompted the delayed implementation of the HPRS in many hospitals, with certain provinces still in the process of system rollout within these healthcare facilities. Consequently, hospital data could not be incorporated into this comparative analysis.

In summary, from the initiation of HPRS implementation in 2014, the FSDoH has documented a cumulative total of 3,803,980 patients and has logged 31,318,403 visits on the HPRS platform, which has been deployed across 219 PHC facilities as of 7 May 2024. Notably, this patient count encompasses individuals who may not be residents of the Free State but have sought healthcare services within the Province (refer to Table 15-4).

Table 15-4: Provincial comparison of HPRS implementation in PHC Facilities (NDoH, 2024; Statistics South Africa, 2022)

Province	Total number of PHC facilities registered on HPRS	Number of PHC facilities using HPRS on 2019-01-01	Number of registered patients on 2019-01-01	Number of visits reported on 2019-01-01	Number of visits reported on 2024-05-06	Population	Number of registered patients on 2024-05-06	% Registered against provincial population
Gauteng	303	294	3 421 093	4 445 246	16 752 072	15 099 422	7 936 811	52.2%
Mpumalanga	293	292	3 114 092	10 729 712	39 449 339	5 143 324	7 301 026	142%
Province		Number of PHC facilities using HPRS on 2014-09-01	Number of registered patients on 2014-09-01	Number of visits reported on 2014-09-01	Number of visits reported on 2024-05-07		Number of registered patients on 2024-05-07	
Northern Cape	176	2	2	7	4 452 780	1 355 946	1 312 926	96.2%
Limpopo	478	14	31	3	18 196 476	6 572 720	6 496 385	98.8%
North West	300	6	7	2	8 862 524	3 804 548	3 280 545	86.2%
KwaZulu-Natal	602	58	328	7	50 431 692	12 423 907	14 333 673	115.4%
Eastern Cape	761	16	100	82	24 839 302	7 230 204	7 794 937	107.8%
Free State	219	5	5	5	31 318 403	2 964 412	3 803 980	128.3%
Western Cape	-	-	-	-	-	-	-	-

The capability of the HPRS to uniquely identify patients enables the FSDoH to distinguish between patients residing in the Free State and those not residing in the Province. For example, the sample of cleaned HPRS data for the Central Unit for Procurement (CUP) for the Free State has 3,670,249 registrations. Of these registrations, 2,880,850 reside in the Free State, and 789,402 reside out of the Province. With the Free State population being 2,932,441, the Province has registered 98.2% of its population (NDoH dashboard accessed 29th April 2024). This shows that implementing the HPRS adds value to healthcare services, enabling the Province to separate residents from non-residents. In addition, this study found that the HPRS improved patient identification, data accuracy, care coordination and decision-making, leading to enhanced healthcare outcomes through the ability to track patients. HPRS-NHLS linkage has improved the availability of patient results during patient care. However, there is still a need to measure the reduction in laboratory costs.

15.5.4 Patient Experience of Care Satisfaction

Table 15-5 delineates the patient satisfaction rates regarding the quality of care across the five districts in Free State, spanning the period from 2016 to 2023. A discernible trend emerges with a consistent rise in patient satisfaction rates across all districts from 2021 to 2023. Notably, in 2023, satisfaction rates surpassed the 70% threshold in all districts except for Lejweleputswa, which stood at 69%. The aggregate patient satisfaction rate was 74.0%, a notable elevation compared to preceding years. The increased patient satisfaction may be attributable to implementing the HPRS-based appointment system, which is instrumental in mitigating patient waiting times at healthcare facilities.

Table 15-5: Comparison of Patient experiences of care satisfaction rate across the Districts (FSDoH, 2024)

District	2016	2017	2018	2019	2020	2021	2022	2023
Fezile Dabi District	74.0	75.0	73.0	66.0	-	69.0	68.0	75.0.
Lejweleputswa	63.0	63.0	56.0	60.0	71.0	58.0	58.0	69.0
Mangaung Metropolitan	79.0	75.0	71.0	71.0	73.0	64.0	69.0	73.0
Thabo Mofutsanyana	71.0	71.0	73.0	74.0	77.0	73.0	74.0	76.0
Xhariep	65.0	68.0	71.0	81.0	-	79.0	72.0	81.0
Free State Province	72.0	73.0	69.0	70.0	73.0	67.0	68.0	74.0

15.6 Discussion

This section discusses the following issues related to HPRS implementation in the Free State Province: 1) the benefits, 2) the challenges, 3) ethical and human rights aspects, 4) the lessons learned during the implementation process, and 5) the relevance of the HPRS to the NDHS 2019-2024.

15.6.1 Benefits of HPRS Implementation

The implementation of the HPRS brings numerous benefits to the healthcare sector in South Africa. It facilitates accurate and efficient patient identification and registration, reduces duplicated records, and ensures patient tracking across different healthcare facilities, especially *lost-to-follow-up* cases (Ariffin et al., 2018; Dhillon, 2021). In addition, the HPRS enhances data accuracy and integrity (Ozair et al., 2015). The availability of HPRS data reflecting patient numbers is crucial for policymakers and operational managers to make informed decisions on leave allocation (Dhillon, 2021; Richemond & Huggins-Jordan, 2023).

In the Free State, implementing the HPRS brought benefits such as reducing waiting times and increasing patient satisfaction. Each patient has a unique identifier (HPRN) allocated by the HPRS, which can be used at any nationwide facility. Another benefit of the HPRS is the expedited retrieval of the patient's records. An appointment system linked to electronic registration facilitates efficient access to health facilities. The current study of the implementation of the HPRS reveals evidence of improved client satisfaction with healthcare services in the Province. Overall, introducing the HPRS has decreased the administrative burden by doing away with multiple folders/registers. It provides an integrated patient history (i.e., one file with all the patient's information). In this way, continuity of care and tracking of patient notes has been advanced. At hospitals, the HPSR enables quick generation of the outpatient (OPD) headcount from one central point. At the provincial level, HPSR implementation eventuated better planning, easier tracking of patient folders from different service points, reduced missing files, and decreased litigation by easier retrieving information required to defend the institution. The HPSR also provides a useful tool for management to identify areas of need requiring support to effectuate improved planning and resource allocation.

The HPRS holds advantages for professional nurses, such as enabling quick retrieval of NHLS test results, which they regard positively because they perceive this to be *part of my work*. The *One Patient, One File* system strengthened tracking of previous clinical care for the clinicians to render quality care to patients. Another benefit of HPRS implementation is that patients can collect their medicine faster and access the appointment system more quickly. The pre-retrieval of files and pre-packaging of medication for booked patients increased patient satisfaction, resulting from reduced waiting time at the facility. The HPRS has been observed to decrease *facility hopping* by patients since it is possible to track the movement of the patients using the HPRN. Finally, because the HPRS is government-owned, no license fees are payable by the Province.

15.6.2 Challenges of HPRS Implementation

The FSDoH is challenged by health workforce deficits (Malakoane et al., 2020). In the context of HPRS implementation at hospitals with multiple administrative staff members, the running of the HPRS is not particularly problematic. However, the opposite is true at some PHC facilities with only one administration clerk. Inadequate human resources and other barriers, such as fragmentation in deployment, software update instability, and lack of standardisation as inhibiting

the full potential of HISs, have also been reported in a systematic literature review (Epizitone et al., 2023). Other challenges encountered included ICT infrastructure limitations, computer theft, resistance to change in some facilities, and the need for ongoing technical support.

An ongoing challenge is the digital divide, particularly in rural areas, where inadequate infrastructure and limited technological access hinder the effective deployment and utilisation of the HPRS. Load shedding is a recurring issue since most PHC facilities do not have generators and, therefore, have to revert to manual registration on paper, whereafter they have to back-capture visits occurring during power outages. Consequently, accurate and up-to-date patient information could not always be maintained, particularly in regions with high mobility where patients receive care from multiple facilities. This lack of real-time data availability negatively impacted the quality of healthcare services and continuity of care delivery.

Training older healthcare staff to use computers and become proficiently acquainted with the HPRS proved more time-consuming than training their younger counterparts. Guaranteeing user adoption through comprehensive training and ongoing support was pivotal for successfully transitioning from paper-based to computer-based workflows. Effective communication with patients during this transition phase was also paramount. This proved problematic when clinic committees were not in place or functional. Additionally, some facilities faced space constraints, leading to filing cabinets being situated away from the Patient Administration System reception area, impacting patient registration and file management.

Since its inception in 2016, the HPRS journey has been long and substantial. However, the HPRS in the Province still fails to capture the vital clinical information required for optimal patient management. Despite ongoing efforts, the system has yet to realise this objective fully.

15.6.3 Ethical and Human Rights Considerations in HPRS Implementation

Digital health information systems (DHIS) are increasingly members of ecosystems, collecting, using, and sharing vast amounts of personal health information (PHI), frequently without control and authorisation by the data subject (Ruotsalainen & Blobel, 2020). From the data subject's perspective, there is often no guarantee and, therefore, no trust that PHI is processed ethically in digital health ecosystems. As outlined in Mittelstadt et al.'s (2011) review, the literature commonly addresses ethical considerations surrounding personal health monitoring (PHM), including privacy, autonomy, medicalisation, social isolation, visibility, and the effects on healthcare providers. However, a thorough examination of PHM's ethical dimensions was notably scarce in the existing literature. Further research was warranted, particularly in areas such as inadvertent monitoring.

Regarding the current implementation of the HPRS in the Free State, the system development phase incorporated internal controls to prevent unauthorised access or hacking of the central database. These controls are subject to auditing by the Auditor General of South Africa at the

national level. The HPRS implementation process did not explicitly outline the ethical consideration; this was embedded in the national HPRS implementation guidelines, South African regulations, the POPI Act and the Free State Governance Policy of 2017 (Office of the Premier, Free State Provincial Government, 2017).

When patients' health data are shared or linked without their knowledge, it undermines their autonomy (Ozair et al., 2015). According to these authors, there are four major ethical priorities for electronic health record (EHR) systems: 1) privacy and confidentiality, 2) security breaches, 3) system implementation, and 4) data inaccuracies. Preserving privacy and confidentiality hinges on restricting access to authorised individuals only. This process commences with user authorisation, where the administrator identifies the user, assesses the level of information required, and allocates unique usernames and passwords. Users are urged to recognise their responsibility in handling accessed information with diligence and accountability, being granted access only to data pertinent to their roles. Thus, assigning user privileges is critical in safeguarding EHR security (Ozair et al., 2015). In the Free State's implementation of the HPRS, patient information security was safeguarded by establishing user rights overseen by the NDoH. A user is required to fill out a user access form (see Annexure A), which their line manager must approve. Once completed, the form is submitted to the provincial office for verification and then forwarded to the NDoH for user creation and approval.

Security breaches risk patient privacy by exposing confidential health information without consent or proper authorisation (Richemond & Huggins-Jordan, 2023; Janarthanan et al., 2024). Security measures such as firewalls, antivirus software, and intrusion detection systems are essential to safeguard data integrity. Employees should not share their identification numbers and always log off when leaving a terminal. In addition to adhering to national regulations, the FSDoH developed a confidentiality document (refer to Annexure B) that prohibits any official from disclosing data to external parties. Each employee tasked with accessing patient data is required to sign this document. Any data sharing must receive approval from the Head of Department. Moreover, the confidentiality document was created to safeguard patient dignity by preventing disclosing health information and patient identities to the public, thus mitigating potential harm.

Concerning system implementation, it is important to acknowledge that healthcare organisations often face significant challenges during EHR adoption, leading to wasted resources, provider frustration, patient confidence erosion, and safety concerns. The development, implementation, and maintenance of EHRs demand sufficient funding and the collaboration of various stakeholders, including clinicians and ICT specialists. Without standardised best practices, users must navigate these complexities independently. To address this, clinics should undertake workflow mapping and standardisation before adopting an EHR system (Richemond & Huggins-Jordan, 2023). In the Free State, facility-specific process mapping and workflows were established, beginning with a facility readiness assessment using a nationally developed tool (refer to Annexure C) and active stakeholder engagement to mitigate these challenges.

Regarding data accuracy, personal integrity must ensure that information remains reliable and unaltered. EHRs are critical in enhancing patient safety by reducing healthcare errors, bridging health disparities, and improving public health. However, the HPRS in South Africa poses the risk of exposing the health data of numerous patients due to errors or theft. Thus, only the NDoH can modify any existing information on the HPRS, provided substantial evidence and justification exist for such changes. Adhering to the Protection of Personal Information Act (POPIA) (Republic of South Africa [RSA], 2013) is crucial, even though it adds complexity to the HPRS implementation process.

Access to HPRS data is limited to individuals possessing a PERSAL number, which serves as a crucial identification credential for government employees. Patients need to be briefed on collecting, storing, and utilising their data during health education sessions conducted in reception areas while awaiting services. Addressing ethical concerns stemming from cultural and linguistic diversity requires utilising culturally appropriate communication methods to ensure that all patients fully understand the registration process.

15.6.4 Lessons Learned During HPRS Implementation

The NDHS 2019-2024 highlights the importance of monitoring and evaluation to assess the effectiveness of digital health interventions (NDoH, 2019, p. 26). For the HPRS, this could involve tracking metrics such as improvements in patient data accuracy, reduced duplicate records, and enhanced healthcare delivery efficiency and patient satisfaction.

HPRS implementation in the Free State generated various lessons that may assist in other provinces and countries. These include the importance of gathering extensive user feedback and iteratively improving the implementation process based on practical usage of the system at the facility level. Another lesson learned was the need to safeguard patient data, comply with relevant regulations such as the POPIA, and monitor potential vulnerabilities continuously. Every official in the facility had to complete a confidentiality document, and they were not allowed to share patient information for any purpose other than patient management in a healthcare facility. The Province had to request reports from the NDoH whenever reports were required, as direct access to draw reports from the HPRS database was unavailable to the Province. The study highlighted the significance of the ICT infrastructure. Although the HPRS can be captured offline, if the patient visits another facility before the system synchronises with the data centre, the patient may have more than one HPRN. Once identified, this issue can be rectified, but establishing the number generated first may be challenging.

Successful implementation of the HPRS requires adequate training and ongoing technical support for healthcare officials at the facility level. It was established that a comprehensive on-site refresher training programme and responsive support channels were necessary to address user questions and issues promptly and effectively. In addition, the scalability and adaptation of the HPRS have enabled the accommodation of an increasing number of patients and the use of the

HPRS-NHLS linkage. Engaging clinic committees, incorporating facility staff's suggestions for optimising Patient Administration System, receiving dedicated support from the provincial executive, effective communication by the NDoH team regarding HPRS implementation, and leveraging insights from the NPT have collectively aided the Province in building community trust, encouraging adoption, and seamlessly integrating the HPRS into the routine Patient Administration System system with minimal disruptions.

Successful implementation of the HPRS requires a prioritised budget for the required ICT infrastructure. Implementation of the HPRS in the Free State was successful because the NDoH provided all the ICT infrastructure for the PHC facilities and hospitals.

As implementing the HPRS is an ongoing endeavour rather than a one-time project, it is imperative to establish continuous evaluation and feedback mechanisms to enhance HIS performance and user satisfaction over time. Establishing clear guidelines and training healthcare staff on data entry protocols helped maintain data quality and integrity. Using the unique HPRN number for filing patient records (facility-held records) has assisted in reducing duplicate records and streamlining patient file retrieval at the facilities. Establishing clear roles at each level of care resulted in the successful implementation of the HPRS in the facilities. Implementing data quality management processes assisted with identifying and correcting errors in patient records. Conducting regular data audits, implementing data validation checks, and providing training on data quality best practices helped facilities improve data accuracy and completeness.

15.6.5 Relevance of HPRS to National Digital Health Strategy (NDHS) 2019-2024

The NDHS 2019-2024 sought to establish an integrated information architecture for interoperability and effective, safe sharing of health information across health systems and services. The implementation of the HPRS in the Free State Province resonates with the overarching goals outlined in the NDHS 2019-2024. The strategy serves as a comprehensive blueprint, steering the nation toward a more unified and digitally empowered healthcare ecosystem. At its core, the HPRS is engineered to establish a robust patient registry and Master Patient Index (MPI) (NDoH, 2019, p. 15). The MPI connects separate patient records across databases (International Federation of Health Information Management Associations, 2018). It contains a record for each patient registered at a healthcare organisation and indexes all other records for that patient. MPIs reduce duplicate patient records and inaccurate patient information (Dougherty et al., 2023).

Interoperability is a critical component of modern healthcare systems, enabling seamless data exchange and improving the quality and efficiency of care delivery (Benson, 2012). A pivotal aim of South Africa's NDHS 2019-2024 is thus to construct an interoperable platform and architecture for healthcare information systems. This implies integration among existing systems like the District Health Information System (DHIS), the Laboratory Information System (LIS), and the Radiology Information System (RIS). The overarching objective of the HPRS resonates with this

vision, striving to assign a unique identifier to each patient, ensuring that medical records are accessible and up to date regardless of the patient's location. This measure streamlines patient management across the healthcare landscape and facilitates seamless patient mobility within and across provinces (NDoH, 2019). In recognising the critical role of effective patient identification, this endeavour enhances record-keeping accuracy, ensures continuity of care, and bolsters patient safety (WHO, 2007).

Furthermore, the NDHS 2019-2024 promotes a person-centred approach to health care (NDoH, 2019, p. 18). The HPRS aligns with this principle by improving patient experiences through enhanced accessibility of health records for HCWs, facilitating more personalised and timely care delivery (Härter et al., 2011).

In summary, the NDHS 2019-2024 provides a comprehensive framework to guide the implementation of digital health solutions, including the HPRS. By aligning with the strategy's goals of patient identification, interoperability, workforce development, governance, person-centred care, and monitoring and evaluation, the HPRS aims to contribute to a more integrated, efficient, and patient-centric healthcare system in South Africa.

15.7 Conclusion

This research contributes to the literature by highlighting the value of participatory approaches in implementing novel HISs in a resource-scarce setting, with implications for policy, practice, and future research. This is the first study that outlines the implementation of an HIS in the Free State. The implementation of the HPRS in the Province presented significant opportunities to improve healthcare delivery and patient outcomes. Despite facing challenges such as inadequate ICT infrastructure, data privacy concerns, and resistance to change, the benefits of the HPRS in enhancing patient management and healthcare coordination are substantial. By leveraging HPRS technology and addressing the underlying challenges, the Free State aims to realise the full potential of the HPRS and advance towards a more efficient and integrated healthcare system. Tracking patients using the HPRN helps the Province reduce *lost-to-follow-up* cases. Also, accessing patients' historical laboratory results helps reduce laboratory-related delays and costs through improved HPRS-NHLS linkage.

In addition, implementing the HPRS in the Free State presents significant opportunities for advancing healthcare delivery and realising the NDHS 2019-2024 goals. The benefits of the HPRS in improving patient management, healthcare coordination, and decision-making are substantial. The HPRS has effectively simplified administrative procedures in both PHC facilities and hospitals, enhancing the efficiency of healthcare operations. Moreover, it has elevated the quality and dependability of health records, subsequently enabling improved clinical decision-making while enhancing the overall patient experience. Various strategies exist to mitigate risks and surmount barriers during HPRS implementation. Leadership, teamwork, flexibility, and

adaptability are pivotal in identifying solutions. It is imperative to maximise HPRS capabilities to bolster healthcare delivery systems' quality, safety, efficiency, and effectiveness.

Further research is recommended to accurately measure the reduction in laboratory expenses resulting from integrating HPRS-NHLS, mainly when the HPRS is optimally utilised across Free State hospitals. Additionally, exploring the integration of the HPRS with the Department of Home Affairs systems could prove beneficial. This integration would aid the FSDoH in confirming the status of patients on chronic medication, particularly those who may have passed away but are still categorised as *lost-to-follow-up*.

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Annexure A: HPRS Access Request Form

Ticket Ref # (Office Use): _____

Health Patient Registration System ACCESS REQUEST FORM (applicable to all users)							
1. Request Type (mark with an **X** where appropriate – only one request type per form)							
New Account		Password Reset		Account Edit/Update		Account Deactivation	
Sections: 1, 2, 3, 4, 5		Sections: 1, 2, 3, 4, 5		Sections: 1, 2, 3, 4, 5		Sections: 6	
2. Applicant Information (a copy of the applicant's identity document needs to accompany this form)							
Name: (as per ID document)				Surname: (as per ID document)			
Date of birth: (yyyy/mm/dd)				South African ID no:			
Cell Phone:				Work Email:			
Current home address:							
3. Employment Information							
Employer:				Employee no:			
Employment type: (Permanent or Temporary)				Designation:			
Employment period:	Start date:			Termination date:			
4. Access Required							
Reason for access required:							

Account termination date:							
Access requested to: (Please provide the full Facility name including district and Province where applicable) Province / District / Sub-district / Facility		Organisational Unit (six digit) code:					

User Profiles required: Indicate with an X Please see profile notes below. Full profile descriptions available online from the HPRS User Manual.	Clerk Operator [1]		Data Manager [3]	
	Report Viewer [2]		System Administrator [3]	
	Facility Administrator [3]		Account Activator [3]	
	Technician [3, 4]		Programme Officer [3]	
	Account Curator [3]			

[1] **Clerk Operator** profile should only be assigned to personnel working at health facilities and actively involved with register patients. This profile may be assigned for multiple facilities, but not for a whole Province, District or sub-district.
[2] **Report Viewer** profile should be assigned to personnel requiring monitoring and reporting capabilities only.
[3] **Profile** require additional training and access approval from NDoH Programme Office.
[4] **Technician** profile also requires the completion of the *HPRS Local Server Access Authorization* form.

5. Declaration

I, ____ (account applicant), declare that the information provided here are accurate to the best of my knowledge. By signing this request form, I agree to:
Not share my account credentials with anyone.
Take responsibility for and do everything in my power to ensure the safe keeping of my login credentials.
Leave nothing on display that may contain my access information such as login names and passwords.
Not use any account, other than the one assigned to me individually, to access the system.
Always log out of my account when leaving the workstation unattended.
Accept accountability for my actions when using the system.
Not provide users with access rights (user profiles) that they do not require to perform their daily duties.
Abide by the rules stipulated regarding the access to and the use of the system.
Never make any form of copy of the HPRS system or the data contained therein.

Signature of applicant:			Date:	
Name of supervisor:				
Signature of supervisor:			Date:	
6. Account Deactivation (use only if account deactivation is required)				
Account name to be deactivated:				
Reason for deactivation:	Generic account		Not in use	
Name & Surname of applicant:				
Signature of applicant:			Date:	
7. Approval (Office Use Only)				
Decision: (Approved / Declined)				
Approved by: (Full name of approver)				
Signature of approver:			Date:	

Annexure B: Health Information Data User Patient Information (Data) Confidentiality Form

health
Department of Health
FREE STATE PROVINCE

CONFIDENTIALITY AGREEMENT
Between

_____
Herein referred as Head of FSDoH
And

_____
Herein referred to as Health Information Data User

PATIENT INFORMATION (DATA) CONFIDENTIALITY
Free State Department of Health Information Management Systems users should: Recognise the right of patients and that health information support official will not disclose any personal and confidential patient information (data which may come in the form of Tier.Net dispatches, back-ups or line lists, HPRS line list and DHIS data) they acquire in the course of their duties, unless the patient agrees to such disclosure, or unless health information support official and or any healthcare worker has a good and overriding reason for doing so (for example, if disclosure is not made, there is the likelihood of serious harm to an identifiable third party, or there is a public health emergency, or any overriding and ethically justified legal requirement).
Personal confidential data items should not be shared at any given point on public platforms or in public gatherings. Patient personal data should only be used at the point of service (clinic, hospital or community service) for patient care unless it is essential for the specified purpose or as directed by the Head of Health (proof directive to be provided).
Patient information (data) should NOT be shared with any official or 3rd party outside the Free State Department of Health employment, unless a DATA USER AGREEMENT FORM is completed and signed by both parties (This form is available in information management directorate at Provincial office).
NOTE: Breach of patient information (data) confidentiality without sound reason and without the knowledge of the patient is a **DISMISSIBLE OFFENCE:**
Core values for health information data user
Integrity: Health information data user should incorporate these core ethical value and standards as the foundation for his/her character and practice as responsible health information data user (SharePoint user).
Truthfulness: Health information data user should regard the truth and truthfulness as the basis of trust in his/her day today activities.
Confidentiality: Health information data user should treat personal or private information as confidential as he/she works with patient data - unless overriding reasons confer a moral or legal right to disclosure.

I _____ (Title, Name & Surname), have understood and agree to the confidentiality agreement accompanying my appointment as a _____ (Position) in the Free State Department of Health.

Health Information Data User
Signature: _____
Date: _____
Supervisor: _____ (Name & Surname)
Supervisor signature: _____
Date: _____

A copy of this form to be sent back to Provincial information management through the office

Approved by

_____ Date _____
DDG Corporate Office Services
Free State Department of Health

Annexure C: CRR-NDoH-HPRS Database

All Fields in GREEN are to be completed		Facility IT Hardware Information			
Facility Network status	Facility Name:		# Com-puters in facility	Facility Type:	
	Contact Person :		0	Facility contact Number:	

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
1. PC OR Server Location									
2. Is the pc plugged into power?									
3. What is the PC used for? (Select multiple if required)									
3.1 Hprs									
3.2 Tier.net									
3.3 Evds									
3.4 Pharmacy									
3.5 Office work									
3.6 RX program									
3.7 VEMR									
3,8									
3,9									
3.10									
3,11									
3,12									
4. Can the pc complete the work it is required to do?									
4.1 If no, why?									
5. PC or PC & server or Stand-alone Server									
6. Operating System									
7. Is the PC too old to be used for the required work?									
7.1 If Yes, elaborate.									
8. What facility network is the PC making use of? (ethernet/wifi/no)									
8.1 If the above answer is wifi, is it strong enough?									
9 Can this PC access the internet?									
10. Can you ping captain salty (146.64.8.39)									
11. Can the computer connect to HPRS? (URL: https://hprs.health.gov.za)									
12. Is there an Antivirus?									

12.1 Antivirus name									
12.2 Is the Antivirus currently up to date?									
13. Is there a Barcode Scanner Connected to the PC?									
14. Is it a 1D or 2D Scanner									
15. Is there is a A4 printer?									
16. A4 Printer Make & Model									
17. Is there is a label printer?									
18. Label printer Make & Model									
19. Are there ethernet ports open in the room?									
20. Comments on the network setup?									
21. Are there sufficient wall electrical points in the room for the equipment?									
22. Are there sufficient multi plug extensions for the equipment?									
23. Is the computer and monitor fastened using a cable lock?									
24. What browser is installed on this computer?									
25. Does the Date and Time of the computer correspond to the current date and time?									
26. General Comments regarding the PC & location of the PC									

Chapter 16: Implementation Support to the Health Patient Registration System: A Historical Operational Perspective

Liebenberg, M.,[1] King,J.,[1] Aucamp, S.,[2] Steenkamp, B.,[1] Burnett, J.M.,[1] Bhana, R.[1]and Visser, R.[1]

[1] Health Systems Trust; [2] MRI Software

Purpose and Introduction: *Since the inception of South Africa's Health Patient Registration System (HPRS) in the public health sector in 2015, Health Systems Trust has been central in supporting the implementation of the system as well as processes towards digital transformation.*

This electronic system uses unique referencing to capture patient demographic data, a fundamental principle for an effective healthcare system. The Health Patient Registration Numbers ensure easier access to demographic data, thus reducing the inefficiencies of manual data entry and minimising the risk of patient misidentification.

Methodology/approach: *The authors chose a qualitative descriptive study to provide straightforward descriptions of experiences and perceptions. Qualitative descriptive research generates data that describe the 'who, what, and where of events or experiences' from a subjective perspective. It best aligns with constructionism and critical theories using interpretative and naturalistic methods. Implementing the system at the facility level commenced with engagements at all health system levels. The basic process was transferring skills in Information and Communications Technology (ICT) to technicians, which began in 2015 and evolved into formalised and structured health systems strengthening implementation approaches. Literature was sourced to support the models and strategies used to enable implementation methodologies, and experiences and lessons learned were shared.*

Findings: *The digital transformation processes, including the adoption of the system during implementation phases, proved to be challenging, requiring consistent application of supportive mechanisms at facilities. The implementation technicians needed intensified training and continued supervision to ensure optimal support. The intensive implementation phase was planned until 2021, followed by the support phases, which focused on activities to achieve sustainability. Connectivity and interoperability of systems have persisted as major constraints since 2015. Sustaining systems requires ownership, stable connectivity, and infrastructure adaptations, ensuring optimised use of hardware (inferred training), software and communications technology, electricity availability, constant support lines, and competent end-users. Gaps in any of these factors resulted in suboptimal deployment of the web-based system in South Africa's public health sector, with the lack of reliable connectivity necessitating the implementation of local servers (virtual machines). In some instances,*

policy enforcement prevented virtual machine implementation, limiting the facilities to the web-based 'thin client' application and nullifying the connectivity mitigations provided by local servers.

Originality/value: *The idea of the digital HPRS is valued as an enabling technological intervention. It is beneficial for real-time and remote communication between facilities, ideally minimising the time used to support end-users and enhancing communication for improved health care. This ability to exchange and share information (as applied through the Health Systems Normative Framework) across the health ecosystem is crucial for quality of care and effective systems operations, saving time and costs and minimising duplications.*

Conclusion: *The HPRS is the referencing system of choice for all establishments in the public health system landscape, specifically in the context of National Health Insurance implementation. It is envisaged that the system should be expanded and rolled out in all public health facilities in South Africa, addressing lessons learnt and finding workable solutions for challenges identified during the implementation and support phases.*

Keywords: *Health Patient Registration System, South Africa, Health Patient Registration Number, Digital Transformation Processes, Health Information Technology Technicians*

16.1 Introduction

The health system fragmentation identified in the 2019 National Digital Health Strategy for South Africa (NDHS) (NDoH, 2019) has existed in settings over many years, particularly in the public sector and in rural areas, resulting in poor or non-existent quality of care and inadequate service delivery (Motsi & Chimbo, 2023). Staffing clinics in rural areas is an ongoing challenge, as is improving accessibility, availability, and smooth health care delivery in the country (Ngene et al., 2023).

The evolution of South Africa's public healthcare service delivery platform through the centuries necessitated the improvement of recordkeeping for legal and other purposes, such as statistical analysis, disease profiling, utilisation and coverage of care, measuring the effect of care, and planning for the population's health needs (Nayak et al., 2019).

Healthcare records were mainly produced manually, with sparse evidence of systems for efficient generation and storage of records (Akinyemi et al., 2022). The core aspect of health service delivery rests on effective communication and accurate use of records. Regardless of all other aspects required for the quality of healthcare delivery, it is legislated that effective records management is a key driver for success and cost management in healthcare in South Africa (Motsi & Chimbo, 2023).

The need for robust healthcare information systems, changes in digital system adoptions, data management, and security measures influence South Africa's planning and policy landscape and shape the roadmap for the implementation of National Health Insurance (NHI) for universal health coverage (Cachalia & Klaaren, 2021; Chitsa & Iyamu, 2020; Villiers, 2021).

The Health Patient Registration System (HPRS) was developed to address the identified need for an electronic and unique referencing system for South Africa (Genesis, 2019). End-users capture patient demographic data on the HPRS, ensuring access to records and facilitating smooth operations between levels of care and the departments involved. South Africa's public health sector implemented the HPRS in 2015 with Health Systems Trust (HST) (Wolmarans et al., 2015).

The capability of the HPRS to generate Health Patient Registration Numbers (HPRN) is equivalent to the Master Patient Index (MPI), using the South African identification number and other forms of legal identification (Wolmarans et al., 2015). The HPRN is designed to ensure easy and reliable access to the patient's medical history and laboratory results, thus reducing the inefficiencies of manual data entry and mitigating patient misidentification pending interoperability of systems (Genesis, 2019). Therefore, The HRPS is essential for gathering information through electronic systems and shaping holistic and universal healthcare delivery, as envisaged by and for the NHI. At the end of March 2018, 2 968 PHC facilities were using the system, and more than 20 million people had been registered on it, compared with 1 849 PHC facilities and 6.3 million registered at the end of March 2017 (NDoH, 2018).

The purpose of this chapter is to present the evolution of processes for the HPRS implementation and associated systems support, including a description of the background and introduction to the implementation and support stages, documented successes of HPRS implementation experiences, and lessons learnt in informing and advocating for the adoption and deployment of the HPRS. The chapter also emphasises the need for and importance of maintaining the HPRS support system that has been developed since inception as a critical requirement for sustainability and quality. A key factor for sustainability will be achieving interoperability through the pending Health Information Exchange (HIE) and building towards improved functionality through effective digital transformation processes, as described in the Digital Health Strategy 2019–2024 (NDoH, 2019).

16.2 Background

Until the early 1990s, South Africa's healthcare system was predominantly manual, with providers relying on paper-based systems and physical registers to maintain patient records and manage billing processes (Akinyemi et al., 2022; Chauke & Ngoepe, 2022). However, the shift towards digital health technologies was prompted by the need to improve record-keeping and streamline processes, as the existing hybrid systems involving both paper and electronic tools often resulted in inefficiencies and heightened costs for healthcare providers due to duplicate data entries and challenges posed by the inconsistent power supply and unreliable backup systems (Mathur et al., 2020; Matlebjane & Ndayizigamiye, 2022). This transformation aimed to bolster the quality of

diagnoses, reduce errors, and enhance patient safety, ultimately addressing the urgent need for precise storage and access to medical information, which had become a priority in light of communication breakdowns and the high incidence of missing records (Matlebjane & Ndayizigamiye, 2022).

This transformation aimed to reinforce the quality of diagnoses, reduce errors, and enhance patient safety, ultimately addressing the urgent need for precise storage and access to medical information, which had become a priority in light of communication breakdowns and the high incidence of missing records (Matlebjane & Ndayizigamiye, 2022).

Adopting electronic patient record management systems was seen as a crucial step in this digital transformation, as it could address the longstanding issues of poor record management, lack of communication among healthcare providers, and inadequate access to medical information (Popela & Dagada, 2016). By facilitating better coordination and information sharing among healthcare professionals, these systems were expected to improve healthcare delivery's overall efficiency and quality and enhance accountability and transparency within the public healthcare sector, ultimately contributing to enhanced patient outcomes (Rahim et al., 2016).

However, minimal interoperability of systems was prevalent, and systems were mostly proprietary (Msomi et al., 2021). Previous procurement options to adopt proprietary systems were exercised by provinces to assist with healthcare systems in mostly hospital environments due to the differentiation of private and public health sectors contributed to provinces' investment in information technology (IT) (Akinyemi et al., 2022).

The decision taken by the National Department of Health (NDoH) to use open-source technology is related to the containment of proprietary database licensing costs, hard-core system coding, and vendor lock-ins (Msomi et al., 2021).

The manual capturing of information resulted in overlapping, which led to individuals capturing information on registers for ease of recordkeeping, especially for Maternal and Child Health, tuberculosis (TB), and HIV records (Beck et al., 2018). Routine data-gathering through the use of the District Health Information System (DHIS) was embedded as practice, and since late 1990/early 2000, data dictionaries and international coding of diseases (ICD-10) were used to provide data to the NDoH (including the Council for Medical Schemes) for informed decision-making (Wolmarans et al., 2015; Genesis, 2019). The District Health Management Information System (DHMIS) policy was formulated and adopted in 2011 (NDoH, 2011). The National Health Information Systems of South Africa (NHISSA) Committee was established to assist provinces with governance aspects specific to the DHIS (NDoH, 2019).

16.3 Methodologies and Strategies

The purpose of this chapter is to present the evolution of processes for the HPRS implementation and associated systems support, including a description of the background and introduction to the implementation and support stages, documented successes of HPRS implementation experiences, and lessons learnt in informing and advocating for the adoption and deployment of the HPRS. The authors opted for a qualitative descriptive study to provide straightforward descriptions of experiences and perceptions (Sandelowski, 2010).

There has also been an increase in the use of qualitative descriptive research embedded in large-scale healthcare intervention studies, which can serve several purposes, including identifying participants' perceptions of why an intervention worked or, just as importantly, did not work and how the intervention might be improved (Doyle et al., 2016). Using qualitative descriptive research can help make intervention studies' findings more clinically meaningful. Qualitative descriptive research generates data that describe the "*who, what, and where of events or experiences*" from a subjective perspective (Kim et al., 2017, p. 23). From a philosophical perspective, this research approach best aligns with constructionism and critical theories using interpretative and naturalistic methods (Lincoln et al., 2017). These philosophical perspectives represent the view that reality exists within various contexts that are dynamic and perceived differently depending on the subject, therefore, reality is multiple and subjective. Therefore, this paper will provide lessons learned because the authors were part of implementing the HPRS in South Africa.

16.4 Initiating the HPRS: Challenges and Methodologies Used During Implementation

The NDoH conducted in-depth research to develop methods for rolling out a demographic system for registering patient details (ultimately the HPRS), primarily for NHI purposes (Genesis, 2019). Since 2016, the debate on the importance of interoperability has been the focus of the Council for Scientific and Industrial Research (CSIR) and formed part of the ongoing evaluation of healthcare systems to establish an optimal framework for systems evaluation. The National Health Normative Systems Framework (HNSF)(NDoH, 2021) addresses the operability of systems to ensure an interface with the HPRS to eliminate the negative effects of the dual healthcare system and fragmentation of systems. The HNSF has been used by the CSIR for conformance testing of all health systems in South Africa, as stipulated in the Digital Health Strategy 2019–2024 (NDoH, 2019).

Among the methodologies developed for implementing the HPRS by the NDoH was the Health System Maturity approach (Wolmarans et al., 2014/2015). In an attempt to evaluate the Health System Maturity model, Woods et al. (2022) suggested that:

> *... the following criteria for a digital health maturity evaluation approach include assessment of the healthcare context, in terms of feasibility, integrity, completeness and action ability of digital health systems. The approach will*

contribute to an objective and methodological process to compare the different digital health systems focusing on the improvement of quality healthcare provisioning, reducing costs, and improving the experiences of healthcare consumers and providers.

The NDoH Health System Maturity approach encapsulated optimised project engagement (a change management component), as well as patient flow processes in facilities, and utilisation of the HPRN or MPI number for filing of patient folders, as described in the Digital Health Strategy 2019–2024) (NDoH, 2019). The HPRN enables easier and more efficient filing; however, the practice thereof varies and is specifically applicable to provincial policies, system maturity, and adoption of the HPRS in the provinces (Wolamarans et al., 2015). An agile project approach was adopted to serve the implementation environment to ensure that short-term turnaround strategies could be implemented and that obstacles could be overcome before the next implementation phase was attempted (Genesis, 2019). The initial stages entailed alpha and beta testing in the NHI pilot districts and upscaling phases to 650, 1,200, and more facilities (mostly PHC facilities) within a planned period of five years (Wolmarans et al., 2015; Walker et al., 2022).

Technology and training considerations were explored multi-faceted, at different intervals, and during reviews of project implementation phases (Chitsa & Iyamu, 2020; Popela & Dagada, 2016). Cognisance was taken of connectivity, and it was discovered that the web-based or 'thin client' approach did not satisfy the goal and trajectory of HPRS implementation, as facilities without Internet connectivity could not utilise the system (Genesis, 2019). A decision was made to add a local server (virtual machine) to the system, enabling continued system use during Internet downtimes and ensuring that data are kept up to date through automated synchronisation with the central server (NDoH 2017a). A prerequisite is connectivity to the servers; therefore, the onsite technician provides the data (Genesis, 2019).

Regular system upgrades were rolled out, requiring routine user acceptance testing to ensure that needs were met and quality maintained. New versions would be signed off and released only once all test cases had passed case testing (Genesis, 2019). The strict HPRS access policy ensures data security and continuous penetration testing at the CSIR to ensure the HPRS has limited risk exposure (Genesis, 2019). The introduction of User Acceptance Testing (UAT) as the final quality control process before the release of new HPRS versions was needed, especially where staff did not have to be physically present at the facility to ensure the upgrade of the HPRS system (NDoH, 2017a).

The support of the system is of critical importance and remains a role and function of the HPRS-qualified technical staff in the field. Various layers of support were introduced, resulting in a definitive three-tiered approach (Genesis, 2019):

- Tier 1: Some access control aspects of the system and minor problem resolution are facilitated. Connectivity is facilitated for Tier 2 HPRS support as and when required.

- Tier 2: HPRS-qualified Technicians facilitate all technical and access control aspects.
- Tier 3: The development partner (CSIR) resolves unresolved issues.

For continued support of the HPRS, there was consensus that training of DoH staff is imperative hence the train-the-trainer (ToT) approach was applied, thereby extending capacity-building to the lowest level of end-users among all DoH and, more recently, District Support Partners' staff (Genesis, 2019). The staffing and resource strategy was adapted as required during various implementation phases. A robust approach accommodated the fast-paced roll-out and targeted provincial implementation to reach as many facilities as possible in the shortest timeframe within stringent low-cost budget constraints. In addition, toolsets were developed to accommodate the allocation of human resources as part of the planning process (Ngene et al., 2023). The scope of the HPRS implementation and support influenced more aspects than anticipated and required continued liaison with DoH staff at provincial and district levels to strengthen governance and reporting processes (Genesis, 2019).

16.5 Governance and Reporting

Project meetings were convened on an ad hoc basis to monitor the political climate within the district that might be inhibiting implementation progress; planned alternative facility visits as needed, and daily monitoring of project progress remotely and in-person. Multiple communication platforms were utilised to ensure that targets were reached by the end of each day, and this practice served as a training method. Reporting was initiated through toolsets for daily monitoring of project progress. The Health Information Tracking Tool, combined with the reporting and planning toolset, was utilised to track actual Technician visits to facilities and provide data on Technician performance on the project (Chitsa & Iyamu, 2020). The combined management of the toolsets enabled the immediate escalation of issues to the Programme Office and mitigating risks.

Following the implementation phase, monthly district-level meetings were held to ensure the system's continued use, and post-implementation meetings were held with the NDoH, which assisted in narrowing and refining the scope of activities.

The need for essential project documentation resulted in the development of a plethora of standard operating procedures, user manuals, and related project documents, which were produced at the national level to guide implementation in provinces. Toolsets were refined as the NDoH adopted newer technologies, such as Google tools for collecting data, cloud solutions for data-sharing, and data visualisation (Genesis, 2019). Member participation in and access to these toolsets is of utmost importance to ensure sustainability, and libraries were created to share the key documents generated during the large-scale roll-outs (Genesis, 2019; Motsi & Chimbo, 2023). The access to essential project documentation resulted in queries from the Auditor-General's Office being managed efficiently within short time intervals.

In their study of the implementation of electronic health records (EHRs) at a hospital in KwaZulu-Natal, Msomi et al. (2021) found that the lack of a well-defined change-management blueprint hindered the implementation of EHRs and had an adverse impact on the improvement of healthcare service delivery. This was also evident in this long-term HPRS project, which necessitated change-management implementation methodologies being explored and implemented as part of the Health System Maturity approach in terms of provincial and district liberations and inductions to the HPRS roll-out (Genesis, 2019). In addition, change management facilitated monitoring and escalation of issues at the operational level to district and provincial teams through HST's Team Leads and Health Information Technology (HIT) Technicians, with support from the project and NDoH programme management teams.

In summary, the HPRS digital transformation was initiated through provincial and district engagements, the HST Technician team engaging with Facility Managers, and transferring skills to Information and Communications Technology (ICT) Technicians at facility and district levels, all of which incorporated an element of change management. During the COVID-19 epidemic, collaborative approaches were applied through the HPRS digital transformation processes to minimise the disruption (Molefi, 2023).

Enforcement of change is effective in the public healthcare environment through legislation. The necessary legislative processes (NDoH, 2018) were followed with the various NHI and HPRS implementation stages. Cognisance was taken of all related legal requirements to ensure the adoption of processes and procedures published in the relevant White and Green Papers. These Acts and Regulations were initiated and promulgated as planned to ensure a concerted movement towards universal health coverage (NDoH, 2017b).

The success of the implementation lies within the ambit of a broader management approach where assessment, planning, implementation and evaluation are crucial to ensure efficiencies, which is especially applicable in the healthcare domain (Genesis, 2019). This approach incorporates documentation of observations and experiences of implementation during the past nine years.

16.6 The Experiences of the Health System Trust During the Implementation of the HPRS

The implementation team's observations are well documented, and validation of success in our approach represents a step towards an enabled digitalisation environment. Completing combined readiness reviews supports assessment processes whereby the systems' landscape is evaluated, whether once or intermittently. The findings yielded by the management toolsets are used for strategic planning and funding purposes to meet the programme's objectives regarding equipment, resource deployment, project process documentation, implementation strategies, and support and training processes. All of these variables are discussed in the following paragraphs. Careful planning and execution of equipment provisioning to healthcare facilities contributed to the success of the HPRS roll-out. This process evolved and matured to coordinate all operations, fulfilling stakeholder needs. Route mapping ensured that hardware was set up in facilities as soon as the

equipment was delivered. Thorough planning and reporting are required to optimise the travel budget. During the implementation phases, rapid turnaround decisions had to be made regarding socio-political issues in different parts of the country. This approach contributed to the synchronisation of actual expenses against available budgets.

Connectivity remains an ever-elusive target to be attained by the provinces and associated departments within the public health sector, a target that aligns with South Africa's achievement of the Sustainable Development Goals. Load-shedding and electrical power breakdowns seriously impact healthcare delivery, especially systems usage, as they interrupt connectivity and hamper technical support, project documentation, and data visualisation. Alternative project strategies were developed to ensure that information can be updated during power outages.

Daily tracking of HPRS implementation progress has been prioritised since the project's inception. The toolsets designed for these purposes were combined, capturing the tasks at hand at each facility, and information for reporting purposes was sourced from this tool. Over the past nine years, the reporting tool has evolved to visualise and upload the data to the National Health Information Centre's data lake, to which all authorised healthcare actors have access.

Continuous support at healthcare establishments necessitates ticket issues being logged on the National Service Centre's Ticket Control database; however, HST's resource deployment strategy enables technicians to service the areas. During stages in which technical staff could not visit facilities, fewer support tickets were logged, and the HPRS system was under-utilised. This factor was frequently raised during collaboration meetings with district teams.

A constant funding stream is needed for continued support of the HPRS and the transitioning of skills to the lowest levels of the healthcare system. Concerted efforts have ensured the inclusion of all District Support Partners to assist with Tier 1 support. Careful consideration resulted in access to the HPRS being reserved for qualified HPRS Technicians to render support at Tier 2 level. A definitive need is to provide training and skills transfer to upskill district ICT staff to sustain the support processes and continue training data capturers at facilities, thus enabling continued usage of the HPRS. Such usage across all healthcare supply chain levels benefits facilities' planning during budgeting and demand cycles. The Health System Trust observed that the usage of information at managerial levels remains deficient and needs more robust intervention and facilitation for buy-in. The change management approach is a constant variable that is crucial for the orientation and training of provincial, district, and facility management cadres on the HPRS and its role in funding health establishments. A change-management approach characterised by a combination of different models could be adapted to suit the needs of the NDoH. These would typically include some elements from models such as the Prosci Change Triangle (PCT), McKinsey's 7S Model for organisation design, the Information Technology Infrastructure Library (ITIL), and the Lippitt- Knoster Model for Managing Complex Change. The variables drawn from these models contribute in one way or another to the successful nationwide implementation of the

HPRS; however, the sustainability of the HPRS is vital to ensure universal health coverage in South Africa.

Since the introduction of the HPRS, a factor that impacted the HPRS data was the misuse of ID documentation (perceived as identity fraud), leading to lucrative criminal business opportunities. The Department of Home Affairs' identity verification process (due to commence in March 2024) must be fast-tracked using biometrics to authenticate the patient's identity. Accurate identification of individuals will assist in the indirect elimination of identity fraud and duplicate costing, for example, where duplicate laboratory tests are completed due to requests from multiple health facilities.

The challenge of verified and non-verified patients is evident for other reasons, such as the influx of foreign patients utilising facility services to obtain medicine and have children born in the country for registration as a South African citizen and the unavailability of Internet connectivity for HPRS synchronisation processes to and from the central server.

Embedding of the HPRS is based on the continuous reinforcement of change management processes. The appointment of suitable systems champions to secure trust in the HPRS is central to sustained internal support within the public health sector.

16.7 Documented Successes of the HPRS Implementations

In a video released by the Free State Department of Health (FS DoH), specific references were made to time containment for patients utilising the appointment system functionality of the HPRS the ease of filing and retrieval of patient records, among other benefits. The FS DoH released an article on 19 December 2023 announcing the digitisation transformation and the incorporation of telemedicine at their clinics (Molefi, 2023).

An evaluation report of Phase 1 NHI interventions in pilot districts, published by Genesis Analytics (Genesis, 2019), reflected the following opinions voiced during a survey of Facility Managers' perceptions:

- The HPRS has improved patient registration at 65% of facilities.
- Patient waiting times had decreased at 51% of facilities.
- Connectivity was categorised at facilities as reliable (at 30%), some reliable (52%), and 18% with no connectivity.

The HPRS is valued as an enabling technological intervention supporting the representation of clinic attendance rates. It is especially useful for tracking real-time transactions in healthcare utilisation. Once the health information exchange (HIE) is fully implemented, the sharing of information (through the application of the National Health Normative Systems Framework) across the health ecosystem will facilitate envisaged outcomes, i.e. improved quality of care and

effective systems operations – saving time and costs, and avoiding duplication of procedures – as inferred by (Wolmarans et al., 2015).

As noted by Amazon Web Services, digital health technology can be a catalyst for improved healthcare systems (AWS, 2021). However, numerous variables exist in South Africa's complex health systems landscape.

To build a more holistic view of digital health transformation, research on the management implications of digitalisation by different stakeholders is greatly needed, as is a further enhancement of digital security and strengthening of technological information systems so that they will be universally accepted by all involved (Stoumpos et al., 2023). As the primary system used in South Africa to draw on patient demographic data, it is deduced that the HPRS could be seen as the required referencing framework for public health systems and, therefore, crucial for proposed expansion and implementation in all of the country's healthcare establishments.

These successes highlight the HPRS Technicians' roles and the adoption of the system at clinics, validating their impact on facilities' usage of the HPRS. Lessons learnt are shared with district, provincial ICT teams and the NDoH Programme Office.

16.8 Lessons Learnt

Table 16-1 summarises the Health System Trust's lessons learnt from implementing and supporting the HPRS.

Table 16-1: Lessons Learnt

Lessons	Observation/Actions	Outcomes
Available connectivity	A maximum of 30% of the facilities had Internet connectivity.	A virtual machine implementation was rolled out successfully. Long-term Evolution (LTE) routers mitigate redundancy and Internet connectivity interruption at facilities.
Multi-system roll-outs	The project scope was narrowed to one system implementation at a time.	HPRS roll-out was successful at more than 3,000 facilities.
Rigid waterfall project approach	An agile project approach ensured quick turn-around times.	The agile approach is functional in this project environment.
Customised district implementation	Understand the systems landscape within provinces, districts and metros.	Provinces must review policies to incorporate virtual machines centrally or at facilities.
Lack of a clearly defined change management framework	Adherence to a change management framework.	Champions are to be identified and held accountable for HPRS uptake and adoption.
Load-shedding in South Africa	Alternative backup power solutions.	Action backup power supply.

The Digital Health Strategy (2019) is one of many instruments that facilitate nationwide change in the South African healthcare landscape; therefore, it is important to clarify where HPRS implementation and continued support align with this strategic context.

A pertinent priority of the National Digital Health Strategy for South Africa 2019– 2024 (NDoH, 2019:31) is the *development of digital health knowledge workers working to support digital health as well as economic development*. For this reason, five strategic principles are articulated: a person-centred focus, expanded access, innovation for sustainable impact, a digital health workforce for economic development, and a whole-of-government approach (NDoH, 2019).

Interoperability and enabling connectivity of all systems proved vital for delivering a harmonised healthcare ecosystem. These factors are dependent on cross-functional support from external and internal initiatives to ensure interoperability, power supply, the verification and validation of South African citizens, and ownership of the HPRS.

The toolsets used to implement, monitor, and report on the HPRS project progress address the last priority of the Digital Health Strategy. These toolsets are developed, maintained and supported with the necessary skills transfer, and data are ingested to the NHIC data lake for easy access to information. In addition, the HPRS supports monitoring of the healthcare landscape to enable further advancements, strategic funding decision-making, and operational efficiencies.

The implementation, support and capacity-building effort laid a sound foundation for continued usage of the HPRS, ensuring a sustainable and trained workforce. A dedicated training schedule is followed to ascertain the potential clients' aptitude for and practical knowledge of the IT systems. The number of DoH field technicians contributing to Tier 1 support has increased.

16.9 Recommendations and Conclusion

- The following recommendations are presented to enhance micro-system support within the health ecosystem and shape the digital health landscape in South Africa.
- A review of the DHMIS policy and standard operating procedures should be undertaken to include all HIS systems and a clear delineation of roles and responsibilities among the various health system cadres as a framework for systems governance and reporting.
- Including the Combined Readiness Review results as part of the demand cycle, is imminent to ensure ownership at the lowest level of the health system, factoring in strict budgetary and financial control.
- It is suggested that systems, in addition to the HPRS, be considered to decrease claims against provinces for technical machine failures and subsequent neglect claims, i.e. the Internet of Things.
- A technical device categorisation for future health resource utilisation and referrals should be lodged in a central repository where healthcare providers could draw information.

- Evidence highlights the need to continue intensified approaches to transfer skills to districts. Such approaches include ongoing training, strict monitoring, and follow-up on the progress of system adoption and usage.
- The mapping of system maturity in each district and province might be considered as a potential solution to encourage competition for achievement, thereby creating digital centres of excellence.
- Securing the advantages of resource set-up in provinces to achieve economies of scale (such as the SyNCH Helpdesk operations per province), established by District Support Partners' projects) will contribute significantly to service coordination and troubleshooting.
- The production of a change management blueprint and SA Digital Maturity structure will be desired artefacts measuring the periodic successes of the HPRS and associated system expansions in the country's healthcare domain.

The success of this evolutionary initiative is ensured through the application of appropriate funding mechanisms, deployment of ICT resources, human capacity-building, and sustainability of the solutions.

We conclude that support of the HPRS and associated systems across South Africa is multi-faceted, contributing indirectly to the 95-95-95 targets of the Joint United Nations Programme on HIV and AIDS (UNAIDS). Collaborative efforts for HPRS sustainability will help to achieve HIV, tuberculosis and sexually transmitted infection epidemic control. They will support the NDoH in attaining universal health coverage through the NHI in South Africa.

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Chapter 17: The Importance of Data Integrity to Ensure the Quality of Address Information in the Master Health Facility List

Maremi, K.J.[1] and Thulare, T.[1]

[1]Next Generations Enterprises and Institutions Cluster, eGovernment Impact Area, Technology Implementation Monitoring and Evaluation (TIME) Research Group, Council for Scientific and Industrial Research (CSIR)

Purpose: *The address information in the Master Health Facility List (MHFL) is key in identifying the location of facilities. The primary responsibility for adding, editing, and deactivating facilities in the MHFL is handled by many health facility representatives from various facilities in various organisations. Facility Representatives must solely ensure the address information they add to the MHFL is valid and the geocode identifies the correct location of the facility; however, this is not always the case. The address information is often inaccurate, which compelled the creation of a data cleaning team to verify these addresses. Thus, this chapter aims to discuss the importance of data integrity to ensure the accuracy, reliability, and quality of address information in the MHFL.*

Study design/methodology/approach: *To understand 'how' and 'why' a certain phenomenon or behaviour operates as it does in a specific setting. This research adopted an exploratory qualitative approach, adhered to the phenomenological design to ascertain the significance of an experience as it is experienced while providing an in-depth description of this experience.*

Findings: *The findings were a lack of accountability, failure to comprehend basic responsibilities as an MHFL user, and user actions on the system compromised data integrity.*

Originality/value: *This study emphasises the importance of data integrity and quality in healthcare. These two factors remain significant and a primary concern in the healthcare industry, especially concerning data stored in health information systems. The research focuses on how healthcare professionals can ensure data quality through data integrity practices in health information systems such as the Master Health Facility List and improve service delivery. The Master Health Facility List provides an accurate and up-to-date compilation of crucial information that enables precise identification of each facility and is the source of National Health Insurance (NHI) facility identification. The data obtained from the Master Health Facility List must be accurate, comprehensive, timely, and consistent.*

Keywords: *Data Integrity, Data Quality, Address Information, Master Health Facility List (MHFL)*

17.1 Introduction and Background

A Master Health Facility List (MHFL) is a comprehensive list of a country's health facilities (both public and private) that includes a set of identification elements for each facility (signature domain) as well as basic information on each facility's service capacity (service domain). A MHFL is also an essential resource for distinguishing registered and/or licensed from unregistered or unlicensed health facilities in the country (Makinde et al., 2018). The World Health Organization (WHO) recommended that each country develop and maintain a consistent, geocoded master facility list (MHFL). This list should include details about health facilities in both the public and private sectors (South et al., 2020). Addresses in the MHFL are particularly significant since they not only provide information about where the facilities are situated but also give direction to persons wanting to find the facilities therefore, the quality of the address information is essential. This introduces the concept of data quality, defined as data accuracy (Mansouri et al., 2023). Data integrity is the most crucial aspect of data quality. Data integrity ensures that the data is correct and has not been improperly adjusted (Tumiso, 2023). Systems must give reliable data to decision-makers since organisations rely on data to make decisions. Additionally, data plays an essential role in healthcare decision-making (Tumiso, 2023). The quality of data used to support decisions directly impacts decision quality; poor data can result in faulty or inaccurate conclusions (Tumiso, 2023). Teh, Kempa-Liehr and Wang (2020), suggest that data is deemed useless if filled with errors since poor data quality produced by inaccuracies can lead to incorrect decision-making results (Teh et al., 2020). In the MHFL, Facility Representatives are responsible for adding the address information of facilities, and these addresses are often inaccurate. Thus, to guarantee the address information's quality, correctness, and dependability, this chapter aims to address the significance of data integrity.

17.2 Alignment with South African Digital Health Strategy

The World Health Organization (WHO) defines digital health as using information and communication technology in the health sector to improve information flow and use for healthcare service delivery and management. The management and organisation of health services must grow in response to the increasing strain on healthcare systems. This includes implementing digital solutions that enable rapid and accurate decision-making (WHO, 2021). The South African Digital Health Strategy is founded on five main strategic principles, notably (NDoH, 2019):

- Person-centred
- Expanded access to services

- Innovation for sustainable impact
- Digital health workforce for economic development

Whole-of-government approach Complying with the national Department of Health's objective of *A long and healthy life for all South Africans*, the strategy presents a vision of *better health for all South Africans enabled by digital health*, given that the latter is expected to be a critical factor in the system's transformation. This approach puts people first to meet the needs of those who can be helped to live healthy lives, those who need medical attention, healthcare providers who provide a wide range of medical services, and managers who have important decisions to make to improve the health system and effectively deliver services (NDoH, 2019).

According to the digital health plan, one of the main problems facing the South African health systems is *inadequate human resources*. The strategy's *Digital health workforce driving economic development* is one of its components. The strategy interventions are improving the technical capacity for digital health and developing a workforce with the skills to support and use digital technologies.

The MHFL provides a precise and current compilation of critical information, making it possible to identify each facility precisely. The President's Summit states that to implement Pillar 9 measures, digital health capacity building and skills transfer are required. The baseline assessment will determine the HIS training needs for the whole health sector. Training people to utilise the MHFL is one aspect of the system. MHFL Generic Training, MHFL User- Led Q&A Sessions, and MHFL Training for Facility Representatives and Curators are among the training topics covered. This training's main objective is to provide participants with the knowledge and abilities they need to go about everyday tasks while interacting with the MHFL system in their environment. Furthermore, people have access to training materials via various web portals. According to former health minister, Aaron Motsoaledi, new staff cadres, creative methods, and skills for existing human resources are needed for effective digital health (NDoH, 2019). MHFL is working toward this objective and contributing to the process. For healthcare to be effectively digitalised, the personnel and customer base must be well-taught to efficiently use existing health technology and systems (Narwal, 2019). To prepare people to become competent workers who support the digital health system, the MHFL program helps build human resources for both new and existing end users for digital health.

17.3 Methodology

The research utilised an exploratory qualitative approach to understanding the *how* and *why* of a particular phenomenon or behaviour in a specific context (Maree, 2019). Du Plooy-Cilliers, Davis, and Bezuidenhout (2014) assert that this type of study usually refers to studying an unknown area. The study followed a phenomenology design to determine the meaning of an experience and provide a comprehensive description of the experience (Maree, 2019). The research aims to explore

the importance of data integrity in ensuring the quality of address information in MHFL. The methodology focused on the individual's experience of the phenomena (Maree, 2019), with inductive reasoning applied to infer theory from collected data (Yin, 2018). The cross-sectional study was less time-consuming and less expensive, as data was analysed simultaneously (Yin, 2018).

To understand the phenomenon under study, the researchers conducted literature reviews in which various authors provided earlier scientific evidence (Yin, 2018). The literature was identified through various sources, including books, conference papers, theses, dissertations, and the Internet. ScienceDirect, IEEE Xplore, Scopus, ProQuest, and Web of Science were the databases used. Google Search was used manually to identify articles not found in the databases. The study examined articles published between 2014 and 2024. The search criteria included data quality, address information, data integrity, and data integrity issues. Several research themes were identified and grouped while assessing the articles, including literature on data integrity practices. The most frequently occurring terms were identified in Figure 17-1 following the literature analysis.

Figure 17-1: Wordcloud summary of main concepts (Wordcloud, 2024)

Yin (2018) states that open-ended questionnaires are primarily employed in qualitative research. Lime Survey, a software solution for online surveys, used an open-ended questionnaire to elicit insights from individuals who participated in the survey. The online poll ran from February 19 to 28 February, 2024, with thirteen (13) participants who completed it. Snowballing, convenience, and purposive sampling were used in this research investigation. The study used snowballing, convenience, and purposive sampling methods, focusing on real-world phenomena rather than statistical inferences. Participants were selected based on their expertise in ICT and availability. The ethical considerations included informed consent, voluntary participation, confidentiality, and privacy. All participants provided informed consent before taking part in this study. Participants were informed of the study's purpose through telephone and email communications. Participants were free to choose to participate and could leave the study anytime if they felt uncomfortable.

Study volunteers were not rewarded for participating, and no harm was done to them. Anonymity and confidentiality were maintained at all times during the data collection process.

Table 17-1: Participant Profile

Position	Years of experience	Number of participants
Data cleaning and Quality Analysis	4	1
Support and Maintenance Supervisor	3	1
Information Systems Practitioner	4	2
Technical Support	1-4	6
System Administrator – Data Manager	19	1
Monitoring & Evaluation	10	1
Artificial Intelligence, Data Science, Machine Learning, Deep Learning, Big Data and Data Governance	7	1

17.4 Literature Review

The literature findings present three (3) critical components that form the basis of this chapter's title: Data Quality, Data Integrity and Address Information. These components are discussed in detail and provide insights on ensuring reliability, accuracy, consistency and validity of the address information provided in the MHFL.

17.4.1 Data Quality

The term quality can relate to intrinsic or essential attributes of an item, but it can also be used when evaluating, grading, or comparing objects (Kindling and Strecker, 2022). Definitions of data quality are frequently supplemented by dimensions that explain broad elements of data quality and criteria that clarify what attributes make data fit for usage in a particular context (Kindling and Strecker, 2022). Below are characteristics of *Good Quality Data*.

17.4.1.1 Characteristics of Good Quality Data

According to Laranjeiro, Soydemir, and Bernardino (2015), The extent to which data characteristics meet the requirements of their purpose (i.e., the quality of a set of data) significantly impacts the outcome of a study. The following are some qualities of good-quality data (Agba and Rijami, 2022):

- Accuracy: The degree to which data attributes accurately indicate the intended object's true value. Good quality data must be accurate, correct, and reliable.
- Accessibility: The degree to which a data set may be acquired and provides a good representation. Quality good data must be available, retrievable, and simple to grasp.
- Consistency: Consistency Is the extent to which a data set is provided in the same unit and format as other similar data sets.

- Validity: The degree to which the fields entered in a data set are correct and fall within an allowed range.
- Completeness: The extent to which a data set contains all values that can be defined as expected attributes. This means that all the data's crucial elements are present.
- Timely: This means a data set is current and ready for immediate use.
- Currency: Currency refers to the degree to which a data set contains attributes appropriate for its years of existence.

The MHFL system aspires to achieve this level of good quality data characteristics despite relying on Health Facility Representatives to enter address information into the system. The recommendation part of this chapter provides suggestions for how to completely implement this in the MHFL system to obtain correct address information.

17.4.1.2 Characteristics of Bad or Poor-Quality Data

Poor or bad data quality refers to data with the opposite characteristics of good quality data, such as incorrect, unavailable, non-consistent, invalid, incomplete, outdated, or untimely. It is the extent to which a data set's characteristics do not meet the requirements of its purpose (Laranjeiro et al., 2015; Agba and Rijami, 2022). Such data could contain duplicates, incorrect figures, misspelt names, and out-of-date information.

The MHFL tries to eliminate the characteristics of insufficient or bad data quality from the system, thus, the NDoH established a team to handle these characteristics and maintain continuous data quality through intensive data cleaning and analysis processes. However, MHFL Health Facility Representatives have access to the system, and when adding/editing a facility, they must provide address information, frequently exposing some of the bad or poor data quality characteristics. To address this, the chapter advocates for the importance of data integrity in ensuring the quality of address information in the MHFL.

17.4.2 Data Integrity

Data integrity is critical to data management, ensuring it remains accurate, consistent, and reliable throughout its lifecycle (Agba and Rijami, 2022; Jordon, 2023). As Jordon (2023) further mentions, data is a valuable asset in the digital age, and managing this data securely is a complex task, as data integrity is not only a best practice but a strategic imperative. Data integrity is essential for maintaining an organisation's brand image and customer trust, as any breach can lead to significant revenue loss and damage to the organisation's credibility or lives lost in healthcare industries (Pandey et al., 2020). Data integrity encompasses various dimensions, including quality, security, and regulatory compliance. It is the foundation for data-driven decisions, information governance, and stakeholder trust (Jordon, 2023). Data integrity can be viewed as a process or a state, with the

former describing measures taken to ensure accuracy, validity, and consistency in research and defining valid and accurate data (Agba and Rijami, 2022).

Address information must be managed, cleaned and stored so that it can be used by consumers, users, and distributors in the MHFL system. The MHFL Team and NDoH are working to ensure data integrity and quality in the MHFL database. As Pandey et al. (2020) mention, data integrity remains one of the most critical concerns for healthcare industries, thus the two teams are continuously working to maintain the precise location of healthcare facilities, ensuring that third-party systems, consumers, and users are satisfied with the services provided as well as that the address information is stored accurately.

17.4.2.1 Challenges in Maintaining Data Integrity

The following challenges exist for maintaining data integrity:

- Data integrity challenges such as data quality assurance, security threats, and the need for regulatory adherence underscore the importance of proactive data integrity practices (Khin et al., 2022). Organisations must adopt proactive data integrity practices to safeguard the reliability and trustworthiness of their data. Proactive data integrity practices are crucial for organisations to maintain credibility, avoid security threats, and comply with legal requirements and ethical standards, preventing erroneous decisions (Jordon, 2023).
- Data Quality Assurance: Involves processes and techniques for assessing, measuring, and improving data quality, ensuring accuracy, consistency, and completeness, as data corruption, incompleteness, or inconsistency can affect the credibility of data-driven decisions (Stvilia and Lee, 2024).
- Data Security: Organisations face evolving data security threats and must protect their data from various threats such as cyberattacks, breaches, and unauthorised access to ensure its integrity (Kuttappa, 2023).
- Regulatory Compliance: Data protection and privacy regulations' intricate nature presents numerous challenges in adhering to legal and ethical standards, which can lead to significant legal and reputational risks (Dhirani et al., 2023).
- Data Governance: Effective data governance practices, policies, and frameworks are crucial for maintaining data quality and security, but establishing clear ownership and accountability for data can be a challenge for many organisations (Jordon, 2023).

17.4.2.2 Opportunities in Maintaining Data Integrity

- High data integrity in an organisation enhances data recoverability, protects against unauthorised access, and maintains compliance. It improves business decision outcomes by increasing analytics accuracy, enabling better-informed decision-making and driving employee and consumer confidence, ultimately benefiting the organisation (Przybycień,

2023).

- Trust and Data Credibility: Maintaining data integrity improves the credibility of business relationships by instilling trust in stakeholders such as partners, customers, and regulatory bodies.
- Data Utilisation: Prioritising data integrity allows organisations to gain actionable insights, improve decision-making, and foster a culture of data-driven operations (Akindote et al., 2023).
- Regulatory Adherence: Regulatory compliance can be significantly enhanced by organisations that maintain data integrity proactively, thereby reducing legal and reputational risks (Kianpour and Raza, 2024).
- Data Lifecycle Management: Involves managing data from creation to archival, ensuring data integrity at every stage, to optimise data utilisation and compliance.
- Data Validation and Verification: Data validation and verification methods ensure data accuracy and reliability, allowing for credible data-driven decisions (Przybycień, 2023)
- Data Auditing and Ethics: Data auditing and ethical data management practices are critical to assuring data integrity, quality, and security (Duggineni, 2023).

The importance of data integrity is evident, and it creates opportunities for the MHFL environment. Multiple consumers can use the MHFL address information because they trust the data's authenticity and accuracy.

17.4.2.3 Data Integrity Issues

Data integrity is a critical concern in the healthcare industry, with potential consequences for patients (Pandey et al., 2020). Health information systems collect and process various health data, including confidential information (Kask et al., 2023). Data integrity issues are persistent, posing health threats and clinician responsibilities, and potential problems like scams, misconduct, inadequate treatment, and data theft make data handling difficult (Zarour et al., 2021). Detecting and minimising data integrity issues can assist in protecting patients and ensuring quality care. Factors such as a lack of awareness of regulatory requirements, staff errors, data accuracy issues, software malfunctions, and configuration problems can impact the MHFL system (Thulare et al., 2020). The next section explores digital health information systems' challenges regarding data integrity, specifically human errors and computerised system issues.

- ***Human Errors Challenges***

Higham and Vincent (2021) describe human errors as conscious decisions made after an incident, while unintentional errors result from poor processes, inadequate training, and misunderstandings (Curz, 2018). Unauthorised information modifications are often caused by user errors and

oversights (Chapple et al., 2021). Unfortunately, the MHFL relies on humans to populate the address information, and any human errors impact the quality and integrity of the address information. Data integrity issues arise from unqualified personnel, inadequate training, improper data capture techniques, inexperienced reviewers, and a lack of qualified personnel. Proper training for employees in digital working environments is crucial for effective record-keeping. All MHFL end users are trained on how to use the system, and there are recurring training sessions where users can ask questions and clarify any misunderstandings. However, the quality of address information remains compromised, so the recommendation part of this chapter suggests, among other things, specialised MHFL training that focuses on address information. Assessing staff's computer literacy and skill level can identify areas for improvement. Regular training is essential for both small practices and larger facilities, as new software, applications, and operational changes often require familiarity with new systems. It also allows associates to brush up on unused skills and concepts (Trader, 2016). Healthcare workers' errors are often influenced by their work environment, which can lead to distractions, inattention, and poor data quality (Vimalachandran et al., 2016).

Staff shortages and high workloads might result in inaccurate and incomplete documentation (Garmendia, Bhansali, and Madhivanan, 2018; Vignesh and Ganesh, 2020). According to Khin et al. (2022) and Vignesh and Ganesh (2020), employees may be compelled to compromise quality to fulfil production targets or schedule events. Healthcare workers often lack awareness or are not prepared to understand processes and procedures during training, leading to them viewing training as an exercise rather than understanding the significance of the training content (Bhuvaneswari and Chandan, 2018; McDowall, 2019; Vignesh and Ganesh, 2020). Staff shortages and high workloads might result in inaccurate and incomplete documentation (Garmendia et al., 2018; Vignesh and Ganesh, 2020). More than one Facility Representative can represent a single facility in the MHFL, reducing the burden on staff personnel to capture this address information. Organisational culture is crucial in addressing these issues, as users may not act due to perceived ease or worth. Fostering an open culture and data security policy can minimise these errors (Lemma, Janson, Persson, Wickremasinghe, & Källestål, 2020; APIC, 2022).

The lack of standardised documentation techniques among healthcare personnel can result in new errors that can be duplicated in subsequent notes (Khela et al., 2024). In general, policies inform and guide an organisation's decisions and missions. Vignesh and Ganesh (2020) mention that procedures are a big contributor to data integrity in that procedures are not thorough enough, leading to variability in performance, missing equipment for data recording and missing data capture. In a data security policy, procedures are defined to protect files, databases, and network accounts (Harrington, 2022). Assigning responsibilities, defining roles, defining audit requirements, outlining enforcement processes, identifying compliance requirements, and establishing acceptable risk levels are all part of the data security policy (Chapple et al., 2021). The term data integrity, however, refers to the validity and accuracy of data rather than its protection. A data integrity policy outlines the procedures that ensure data integrity. These procedures include

but are not limited to preventing unauthorised data inputs/outputs, rejecting invalid data inputs, and safeguarding data and programs against accidental or malicious modifications (Duggineni, 2023). Organisations face a challenge in maintaining data integrity due to inadequate training for healthcare workers. To address this, incorporating data integrity principles into digital health information systems and procedures is crucial (Gribbin, 2017). Healthcare workers have been unable to understand data integrity procedures due to inadequate training (Vignesh and Ganesh, 2020). Training personnel in good documentation practices can prevent and detect issues. Specific training may be necessary for computerised systems used in data generation, processing, interpretation, and reporting, ensuring everyone contributes to maintaining data integrity (WHO, 2020). Healthcare institutions must develop and implement a data integrity policy in parallel with their data security policy (Thulare, 2023).

- ***Computerised Systems Challenges***

Digital health systems and other health information technology may replace outdated, disjointed paper-based health record systems (Paul et al., 2023). However, data collection and analysis in computerised systems is a complex process with numerous technological challenges. Non-interoperable Health Information Systems (HISs) and lack of design, recording, and management standards can lead to inconsistent statistics (Ebnehoseini et al., 2022). Computer viruses pose a significant threat to HISs, and data integrity management can be compromised due to inadequate system control (Wager et al., 2021). Computerised systems must be validated to ensure accuracy, reliability, and consistency. Security processes must be implemented to maintain data integrity to prevent unauthorised access and data changes (European Medicines Agency, 2021).

Authorisation records with detailed access levels must be maintained, and user roles should be recorded. The design, security, and use of computer programs and data files are controlled by a combination of software, hardware, administrative, and data security controls (PIC/S, 2021). Software errors in HISs can damage, delete, or place medical records incorrectly. The complexity of HISs can make them difficult to use, leading to errors (Chapple et al., 2021). Copying and pasting risks, such as incorrect or outdated information, can lead to health risks and liabilities (Champagnie, 2019). Healthcare facilities lack a rigorous, real-time approach to assess safety and identify integrity issues (Sittig et al., 2018). Insecure networks can expose HISs to unauthorised access and falsification. Integrated delivery networks must develop techniques for creating, transmitting, and enforcing standardised data integrity policies and procedures. Techniques for maintaining data integrity in computerised healthcare systems include risk-based validation, selecting appropriate systems and service providers, auditing audit trails, change control, using IT quality and validation systems, planning for business continuity, accuracy, and archiving regularly (Kucharski, 2016; Maunu, 2019; Marley, 2020).

- ***Address Information***

Addresses are essential for governance because they can be used as a link between all kinds of information (Coetzee, Cooper, and Katumba, 2020). Similarly, addresses are essential for the MHFL as they direct people to where to access health facilities. Addresses can be defined as any specification that refers to a unique location on Earth and is an association between people and their spatial surroundings (Javidaneh, Karimipour, and Alinaghi, 2020). The importance of addresses became specifically apparent during the COVID-19 pandemic. The geocoding of COVID-19-positive test case addresses was hampered in South Africa, amongst others, by the lack of cross-jurisdictional address data. Although the COVID-19 era has passed, the importance of addresses remains explicit in the MHFL, and it is crucial to ensure they are precise, so facilities are accessible at all times. The mandate to assign addresses and maintain address data lies with municipalities. Each municipality maintains address data for its area of jurisdiction according to its own specific data model that satisfies the organisational objectives of the municipality (Tredrea, Coetzee, and Rautenbach, 2020).

To facilitate standardisation of addressing, the South African Bureau of Standards (SABS) developed the 'Geographic Information – Addresses' set of standards, namely SANS 1883 Parts 1 to 3. Due to their importance in responding to the COVID-19 pandemic, SABS made the SANS 1883 standards freely available (SABS, 2020). In SANS 1883, an address is defined as an unambiguous specification of a point of service delivery (SABS, 2020; Tredrea et al., 2020). Organisations like the South African Post Office and AfriGIS implement SANS 1883. However, numerous organisations still do not follow the standards. AfriGIS Search is an address verification, capture and geocoding tool. It contains intelligence to simplify the complex addressing system of South Africa. Therefore, integration into a single dataset requires transformation from an organisation-specific data model into a standardised model (McKenzie et al., 2019). The quality of address information exported from various organisations in South Africa shows that many organisations do not adhere to the address standards defined by SABS, as the address information is poor and incorrect. The MHFL works hard to clean up these addresses and maintain data integrity when imported into the system.

An address is therefore, used to facilitate the delivery of one or more services by one or more providers (Coetzee et al., 2020). Service delivery includes utility services such as water, sewerage, telecommunications, and electricity supply; refuse collection; billing; postal and courier delivery; emergency response; goods delivery; serving summonses; household surveys; and visiting. Addresses are also critical for services not necessarily performed at the address, such as opening bank accounts or buying on credit. The MHFL contains facility address information, and anyone who accesses the facilities has access to all services rendered there.

Addresses are not just for people, organisations (government departments, businesses, non-governmental organisations, etc.) or buildings (dwellings, offices, factories, etc.). They are also necessary for (Coetzee et al., 2020):

- Undeveloped erven.
- Open spaces, such as parks.
- Crime or accident scenes are used to direct emergency personnel accurately. For example, these addresses can be specified relative to a landmark by giving the nearest street intersection or as a specified distance in a specified direction along a linear feature, such as a road. Addresses can therefore, be permanent or transient.

You must know their address if you have relatives in South Africa and want to send them a letter or a parcel. All addresses in South Africa contain a postcode, one of the most critical parts of the address according to the South African National Standard for South African addresses (FinGlobal, 2019). In some countries, people have different residential addresses and different postal addresses. However, in South Africa, unless you have a separate Post Office Box where you receive all your mail and parcels, your residential address is your delivery address (FinGlobal, 2019). This address facilitates the delivery of anything from letters to utility bills to courier parcel deliveries and other services. If you are to receive anything at your home in South Africa, your address must conform to the South African National Standard for South African addresses (FinGlobal, 2019). Postal codes and address information play a vital role in the MHFL. All addresses are expected to have a postal code.

17.4.2.4 Address Types as Listed in SANS 1883-1

To explain the vast range of address types used in South Africa, the draft South African address standard (SANS 1883) draws on similar standards from other countries as well as the extensive knowledge of its project participants. The present draft standard comprises eleven kinds of addresses: a street address, a building address, an intersection address, a site address, four types of South African Post Office addresses, a landmark address, a farm address, and an informal address (Coetzee et al., 2020). The MHFL is specifically interested in the following address types: street, landmark, building, site, village, farm, informal addresses, and postal codes. The following types of addresses are listed in SANS 1883:

- Street address – In its most basic form, a street address consists of a street name and a location. The indication of street numbers is optional. The term locality can refer to a suburb, town, municipality, province, or country, including an optional postcode (McKenzie et al., 2019; Coetzee et al., 2020). The MHFL requires a street name and a street number. However, not all of these fields are mandatory because some areas do not have street names or numbers. Based on the MHFL address database, most townships lack street numbers, and most villages lack both street names and numbers.

- Intersection address – Without a street number, this address type specifies a place at the intersection of two streets (McKenzie et al., 2019). This is apparent in the MHFL, where street names are listed as cnr this street and that street name.
- Landmark address – Sometimes, a landmark's name, along with the name of the locality, suffices to provide a clear description of the place. The landmark address type covers these addresses. However, street information is not always included (McKenzie et al., 2019). This is encouraged in the MHFL, especially during training sessions, because facilities in rural locations often do not have complete address information. Presenting a landmark aid in facility identification—for example, a facility named five kilometres from a police station, school, or hospital.
- Building address – The building information includes a unique building identifier in addition to unit and floor details. Several buildings are grouped and called by a common name, such as the name of the complex, and are catered for. Specifying the name of the building, floor, or unit also assists in identifying address information in the MHFL, as some health facilities operate in malls.
- Site address – In South Africa, addresses (unambiguous descriptions of service delivery places) consist of merely an address number and a locality. Site addresses were largely used in townships formed during apartheid when house numbers were allotted per block or section in a township, but no street names were assigned. In rural areas, the second form of site address identifies the location of a farm or agricultural holding by referring to the Surveyor-General's cadastral record of the property's location. The third type of site address is new and occurs in security estates where the property is described using a cadastral erf number coupled with a name for the location. These are critical in the MHFL as they identify the actual site of the facility.
- Farm address – A farm address consists of a farm name given by the farm's occupant or owner and the town's name or colloquial geographical area. The farm address additionally allows for an optional building name that identifies either the specific house of a tenant or another facility on the farm that operates as a service delivery point (McKenzie et al., 2019). Many of the MHFL facilities are located in farms, especially schools, and the address information of these facilities is often difficult to verify.
- Informal address – The minimum prerequisites for an informal address are a description of the address in a free format and a location. The address type allows for optional street, intersection, or landmark information. Although this address type benefits data interchange, the official allocation of informal addresses is not encouraged (Coetzee et al., 2020). These are evident in the MHFL, especially the tribal authorities.
- SA Post Office address types – The South African Post Office specifies four address types for postal mail delivery: PO Box, street, poste restante, and SAPO-type rural village addresses. These address types are also recognised by Postal Address Management Service

Suppliers (PAMSS), which the South African Post Office accredits to certify addresses for bulk mailing (PAMSS-certified addresses receive a significant postage discount). SAPO box address. This comprises a PO Box or Private Bag description, post office name, and postcode.

- SAPO street address – The postcode is required in the Post Office Street address type, but the locality name might refer to a place or a post office. The locality name in the South African Post Office Street address is limited to Post Office-approved names. The Post Office Street address type is not a subset of the street address type since the street address type does not allow a Post Office name.
- SAPO poste restante address – This is a service in which a post office retains mail for a certain length before handing it over to the addressee in person. Internationally, this is commonly used for guests who do not know where they will be staying ahead of time. It is also used by people in South Africa and other nations who have yet to be assigned a postal address. The poste restante address must include the recipient's full name (to be verified against their identification document or passport) and the post office and postcode. The sender should also provide their return address, but it can be found elsewhere on the envelope and is not part of this address type.
- SAPO-type village address – Finally, a Post Office-type village address includes a house number, an optional village name, an obligatory place name, and a postcode. The house number comprises three sets of numbers that indicate (from left to right) the village, section, and home. The place name and postcode are for the post office closest to the village. The Post Office has been assigning these addresses to residences in remote communities, therefore making a substantial contribution to the development of the people in these places by allowing them to receive mail, furniture, and other products or service deliveries.

Therefore, correct addresses are essential for good governance of municipal assets, financial management, service delivery and emergency response. Additionally, addresses are important beyond governance and urban management: they provide individuals with an identifiable location in the city as both a physical and a symbolic connecting point to society (Coetzee et al., 2020). In the MHFL system, correct addresses are essential for facility identification and building trust from system consumers.

17.4.2.5 Geographic Location

ISO (International Organization for Standardization) is a global federation of national standards bodies (ISO members). ISO technical committees are often responsible for the preparation of international standards. Every member of a body keen on a subject for which a technical working group has been formed has the right to have a representative on that committee. Both governmental and non-governmental international organisations collaborate with ISO in their work. ISO works closely with the International Electrotechnical Commission (IEC) in all aspects of electrotechnical

standardisation (ISO, 2022). ISO 6709:2022 provides a standard representation of geographic point location using coordinates. Geographic point location (GPL) describes a well-defined geographic location using a single coordinate tuple. Efficient exchange of GPL data necessitates universally interpretable formats and allows the identification of places on, above, and below the Earth's surface. Users from diverse disciplines have varied requirements. This is demonstrated by the usage of degrees and decimal degrees, as well as the traditional degrees, minutes, and seconds, for measuring latitude and longitude. User applications may also require different levels of precision and can use latitude and longitude without height (ISO, 2022).

Geographic location is important in several socioeconomic and environmental decisions, such as choosing sites for new enterprises or delivering location-based services (Singh, 2017). In locating prospective regions for grid-connected offshore wind power development, assigning coordinates (latitude and longitude) to a physical location has helped many sectors enhance performance through spatial analysis (Singh, 2017). However, the geospatial analytics community has always been concerned about the quality and dependability of geocoded data (Singh, 2017). Geospatial data, such as administrative boundaries, property information, addresses, roadways, and utility networks, form the foundation of municipal governance. A spatial data infrastructure (SDI) is often used to enhance the availability, accessibility, and usefulness of such data and related services. This involves careful stakeholder coordination and an information-driven approach to unleash the value of geographic data (Coetzee et al., 2020).

Geocoding is exceptionally susceptible to error for various reasons, including lack of coverage (local vs. around the globe), absence of thorough, correct, consistent, and updated reference databases, and the making of wrong assumptions (Singh, 2017). Furthermore, inaccurate geocoding might bias spatial analysis results, leading to misclassification of actual physical locations, which can harm research outputs or location-based business decisions. Therefore, recognising and overcoming these geocoding problems is crucial (Singh, 2017). As stated in Section 3.4 below, it is clear that many Facility Representatives offer incorrect geocodes, and accountability is required to guarantee the correct geocodes are provided. According to Singh (2017), geocodes are prone to error, possibly due to various factors. The most significant factors appear to be incorrect assumptions and the need to proceed to the next page of registration in the MHFL, which must be addressed to ensure the quality of address information in the MHFL.

17.4.3 The Master Health Facility List (MHFL)

In the designated facility or facilities, a Facilities Representative acts as a liaison for matters about the facilities and is frequently the main point of contact for departmental staff and other customers. They are also in charge of looking into or organising responses to complaints, emergencies, special events, and other issues about the facilities (PennState, 2024). In the MHFL, A Facility Representative is appointed by an organisation, institution, or facility to function as an MHFL user. They oversee adding or editing facility details, such as facility manager. Their responsibilities

include creating requests to add or edit facility details, such as outreach and vaccination services, deactivating facilities, registering on the MHFL to obtain access, and viewing all facility data (NDoH, 2021). To ensure compliance and alignment with the Digital Health Strategy, these Facility Representatives were trained to utilise the system.

Figures 17-.2 and 17-.3 show the address section of the MHFL system, where Facility Representatives are required to enter facility addresses. As seen in both pictures, the address type can be filtered as urban or rural, and each requires a unique set of information.

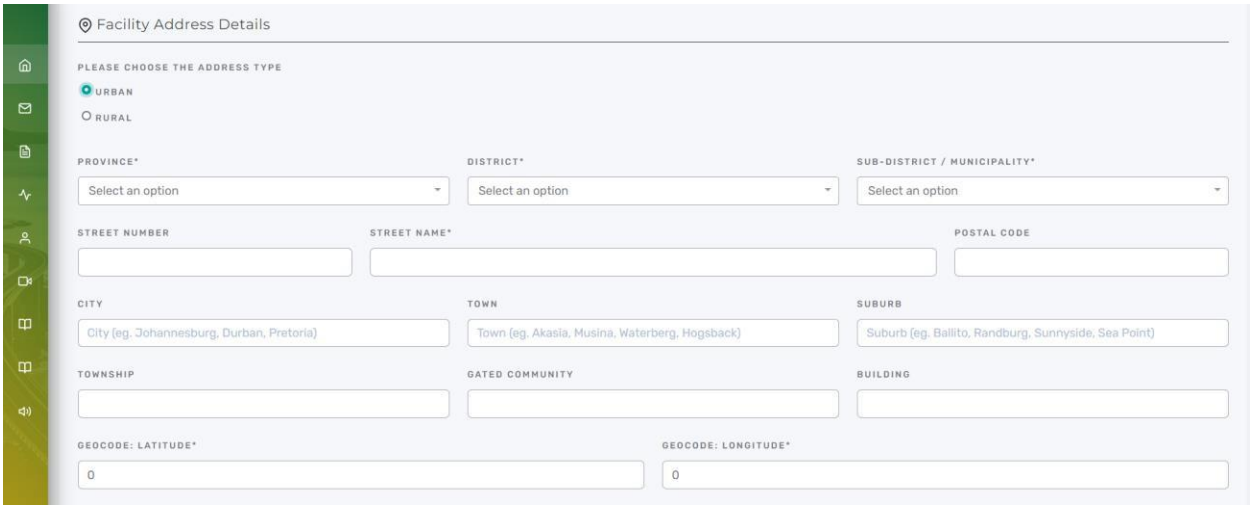


Figure 17-2: MHFL Urban Address

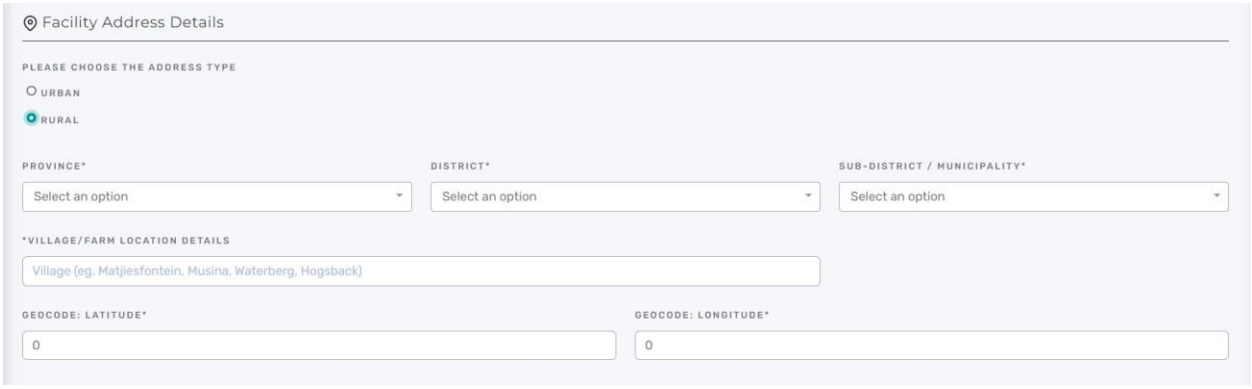


Figure 17-3: MHFL Rural Address

- ***Address Information Challenges***

Unfortunately, the address information populated by these facility representatives in the MHFL is inaccurate. Often, they duplicate the address information, e.g., if they are unsure whether a specific area is a suburb, town, city or township, they copy and paste the name of the area in more than one subcategory, thus ending up with an area represented more than once in MHFL. Additionally, these users are responsible for entering address information into the MHFL because they have been appointed as Facility Representatives, which means they should be familiar with the address information of the facilities they represent. However, many users have never visited the facilities and thus enter incorrect address information. For example, suppose they are based in an organisation's head office and represent multiple facilities. In that case, they submit facility requests using the same address information for the head office rather than the actual facility. Furthermore, the MHFL system has mandatory areas in the address section that oblige Facility Representatives to enter information, and geocoding is one of them. After realising this, the Facility Representatives simply input incorrect geocodes, directing patients, distributors, vaccinees and anyone seeking to access the facility to the middle of nowhere, people's houses, or a whole different location.

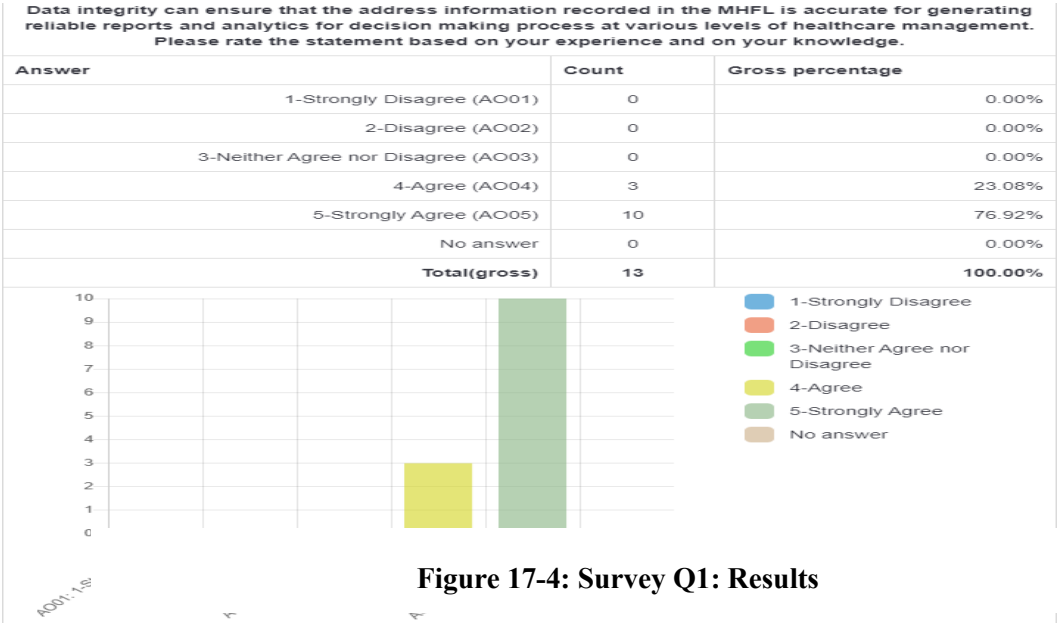
As a measure put in place to mitigate this problem, the National Department of Health (NDoH) put together a group of data cleaning and analysis teams to verify this address information. The Facility Representatives are often trained, and emphasis is placed on ensuring the address information is clean, accurate, and precise. Furthermore, the NDoH has prepared training material demonstrating how to obtain correct facility geocodes using a computer or cellphone device to input into the MHFL (NDoH, 2022). Users are also shown where in the MHFL they can access the document to refresh their minds.

Despite these attempts, the Facility Representative continues to submit incorrect address information. This raises the concept of data quality and data integrity in the MHFL, for which Facility Representatives must take accountability. Mdleleni (2022) states that addresses are lists of structured information that aid in location discovery. Address information is also exported from other health establishments that are integrating or will be included in the MHFL database. Before this information can be uploaded to the system, the data cleaning and analysis team goes through a rigorous data cleaning, analysis, and verification procedure to ensure that the information imported into the MHFL is of high quality. However, Facility Representatives have access to this information, and at any point, they can change the address information and populate incorrect data sets, therefore the recommendation section of this chapter provides suggestions on how to manage this.

17.5 Results

A survey study was conducted to understand the importance of data integrity in MHFL, involving 13 professionals from various areas of the MHFL system. The findings were presented in this

section, highlighting the diverse viewpoints of participants based on their level of expertise and the crucial role of data integrity in ensuring quality address information. All participants agreed with the statement. 76%.92 of the participants strongly agree.

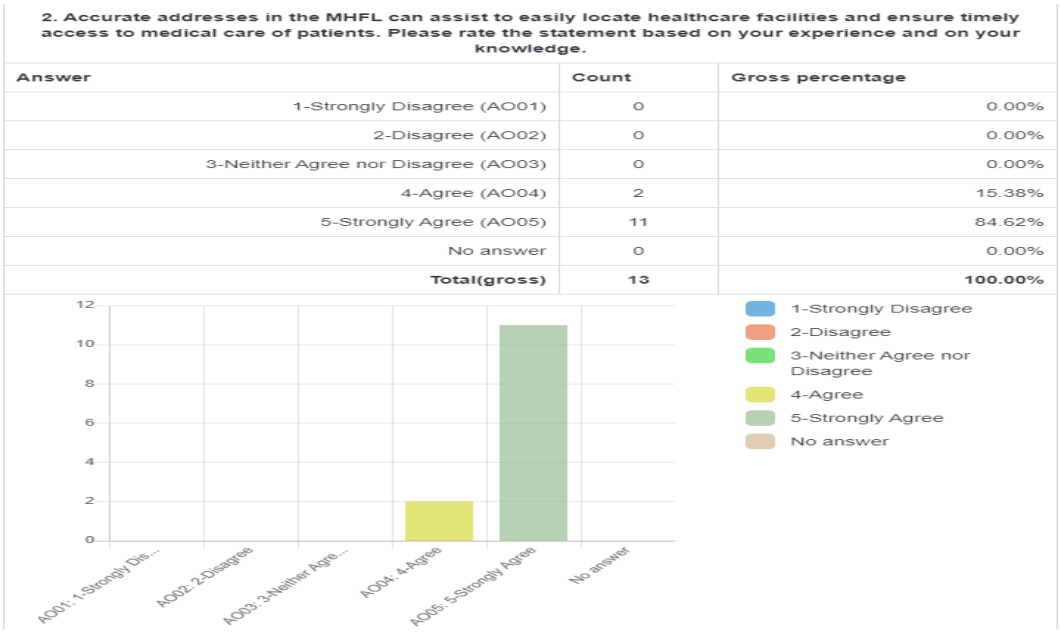


Data integrity can ensure that the address information recorded in the MHFL is accurate for generating reliable reports and analytics for decision making process at various levels of healthcare management. Please rate the statement based on your experience and on your knowledge.

Answer	Count	Gross percentage
1-Strongly Disagree (AO01)	0	0.00%
2-Disagree (AO02)	0	0.00%
3-Neither Agree nor Disagree (AO03)	0	0.00%
4-Agree (AO04)	3	23.08%
5-Strongly Agree (AO05)	10	76.92%
No answer	0	0.00%
Total(gross)	**13**	**100.00%**

Figure 17-4: Survey Q1: Results

It is evident that 84.62% of the participants strongly agree with the statement. While 15.38% only agree.

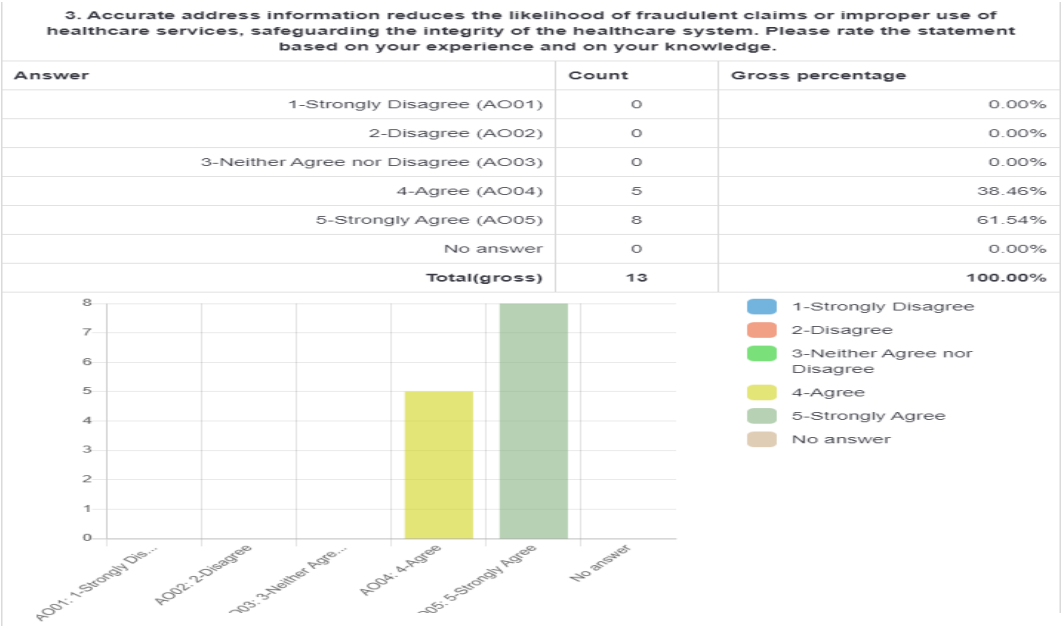


2. Accurate addresses in the MHFL can assist to easily locate healthcare facilities and ensure timely access to medical care of patients. Please rate the statement based on your experience and on your knowledge.

Answer	Count	Gross percentage
1-Strongly Disagree (AO01)	0	0.00%
2-Disagree (AO02)	0	0.00%
3-Neither Agree nor Disagree (AO03)	0	0.00%
4-Agree (AO04)	2	15.38%
5-Strongly Agree (AO05)	11	84.62%
No answer	0	0.00%
Total(gross)	**13**	**100.00%**

Figure 17-5: Survey Q2 Results

It can be seen that 61.54% of participants strongly agree with the statement, while only 38.46% agree.



3. Accurate address information reduces the likelihood of fraudulent claims or improper use of healthcare services, safeguarding the integrity of the healthcare system. Please rate the statement based on your experience and on your knowledge.

Answer	Count	Gross percentage
1-Strongly Disagree (AO01)	0	0.00%
2-Disagree (AO02)	0	0.00%
3-Neither Agree nor Disagree (AO03)	0	0.00%
4-Agree (AO04)	5	38.46%
5-Strongly Agree (AO05)	8	61.54%
No answer	0	0.00%
Total(gross)	**13**	**100.00%**

Figure 17-6: Survey Q3 Results

It can be observed that 84.62% of the participants strongly agree with the statement. While 15.38% only agree.

4. Reliable address information can enable healthcare providers and policymakers to effectively plan and deliver healthcare services. Please rate the statement based on your experience and on your knowledge.

Answer	Count	Gross percentage
1-Strongly Disagree (AO01)	0	0.00%
2-Disagree (AO02)	0	0.00%
3-Neither Agree nor Disagree (AO03)	0	0.00%
4-Agree (AO04)	2	15.38%
5-Strongly Agree (AO05)	11	84.62%
No answer	0	0.00%
Total(gross)	**13**	**100.00%**

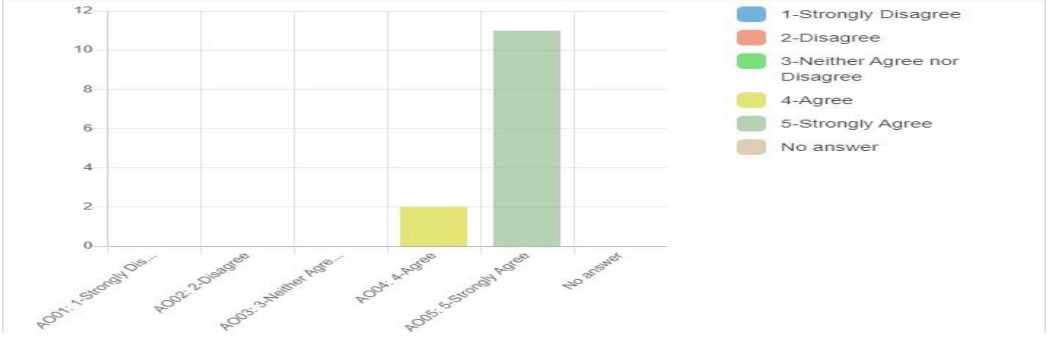


Figure 17-7: Survey Q4 Results

The participants generally agreed upon the statement. A response of 76.92% strongly agreed.

5. Reliable address information can enable policymakers to identify areas of inadequate healthcare infrastructure and allocate resources accordingly to address gaps and improve access to care. Please rate the statement based on your experience and on your knowledge.

Answer	Count	Gross percentage
1-Strongly Disagree (AO01)	0	0.00%
2-Disagree (AO02)	0	0.00%
3-Neither Agree nor Disagree (AO03)	0	0.00%
4-Agree (AO04)	3	23.08%
5-Strongly Agree (AO05)	10	76.92%
No answer	0	0.00%
Total(gross)	**13**	**100.00%**

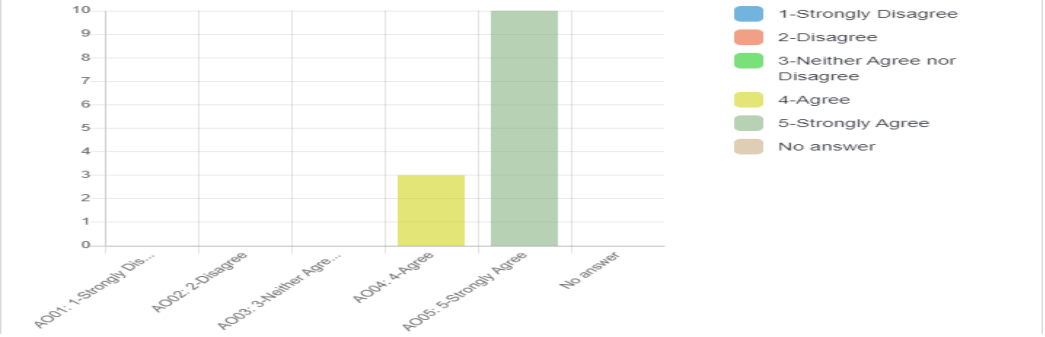


Figure 17-8: Survey Q5 Results

The participants generally agreed upon the statement. A response of 84.62% strongly agreed.

6. Data integrity can safeguard patient safety by ensuring that accurate address information is available when it is needed. Please rate the statement based on your experience and on your knowledge.

Answer	Count	Gross percentage
1-Strongly Disagree (AO01)	0	0.00%
2-Disagree (AO02)	0	0.00%
3-Neither Agree nor Disagree (AO03)	0	0.00%
4-Agree (AO04)	2	15.38%
5-Strongly Agree (AO05)	11	84.62%
No answer	0	0.00%
Total(gross)	**13**	**100.00%**

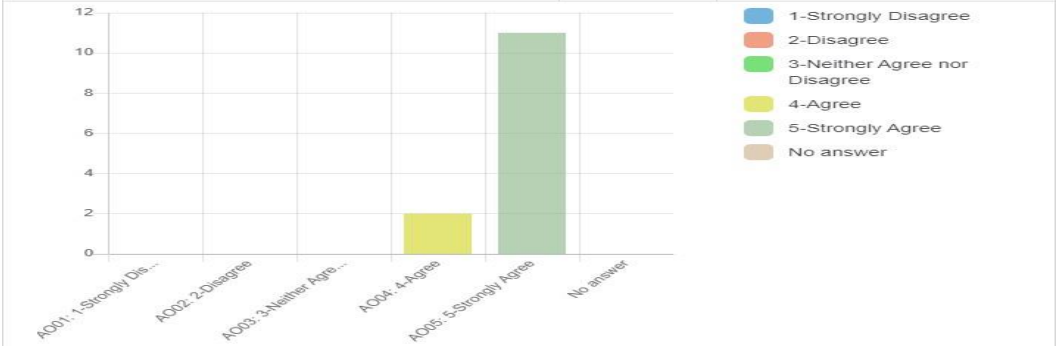


Figure 17-9: Survey Q6 Results

It is shown that 53.85% of the participants strongly agree, while 7.89% neither agree nor disagree.

7. Data integrity enables data analysis and research of address information for researchers to study disease patterns, assess healthcare disparities and evaluate the effectiveness of healthcare interventions. Please rate the statement based on your experience and on your knowledge.

Answer	Count	Gross percentage
1-Strongly Disagree (AO01)	0	0.00%
2-Disagree (AO02)	0	0.00%
3-Neither Agree nor Disagree (AO03)	1	7.69%
4-Agree (AO04)	5	38.46%
5-Strongly Agree (AO05)	7	53.85%
No answer	0	0.00%
Total(gross)	**13**	**100.00%**

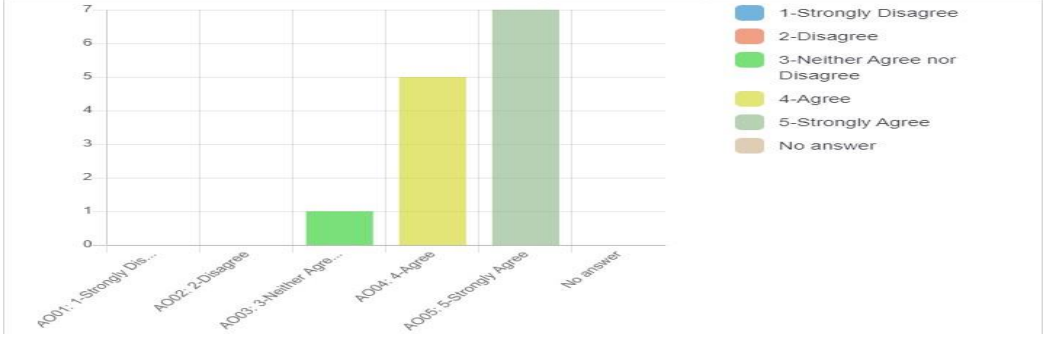


Figure 17-10: Survey Q7 Results

The responses of the participants vary differently. 69.23% of the participants strongly agreed with the statement. While 7.69% strongly disagreed and another 7.69 neither agreed nor disagreed.

About 70% of the participants strongly agree with the statement.

8. Ensuring data integrity in the MHFL can assist healthcare organizations meet regulatory requirements and avoid penalties associated with non-compliance. Please rate the statement based on your experience and on your knowledge.

Answer	Count	Gross percentage
1-Strongly Disagree (AO01)	1	7.69%
2-Disagree (AO02)	0	0.00%
3-Neither Agree nor Disagree (AO03)	1	7.69%
4-Agree (AO04)	2	15.38%
5-Strongly Agree (AO05)	9	69.23%
No answer	0	0.00%
Total(gross)	**13**	**100.00%**

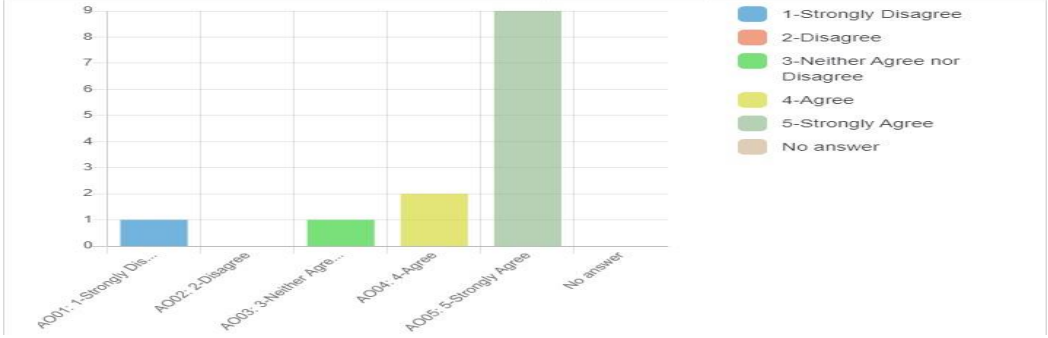


Figure 17-11: Survey Q8 Results

9. Maintaining data integrity in the MHFL enhances trust and confidence in the healthcare system as patients, users, and stakeholders expect reliable information to be available when making healthcare-related decisions, and data integrity ensures that this expectation is met. Please rate the statement based on your experience and on your knowledge.

Answer	Count	Gross percentage
1-Strongly Disagree (AO01)	0	0.00%
2-Disagree (AO02)	0	0.00%
3-Neither Agree nor Disagree (AO03)	0	0.00%
4-Agree (AO04)	4	30.77%
5-Strongly Agree (AO05)	9	69.23%
No answer	0	0.00%
Total(gross)	**13**	**100.00%**

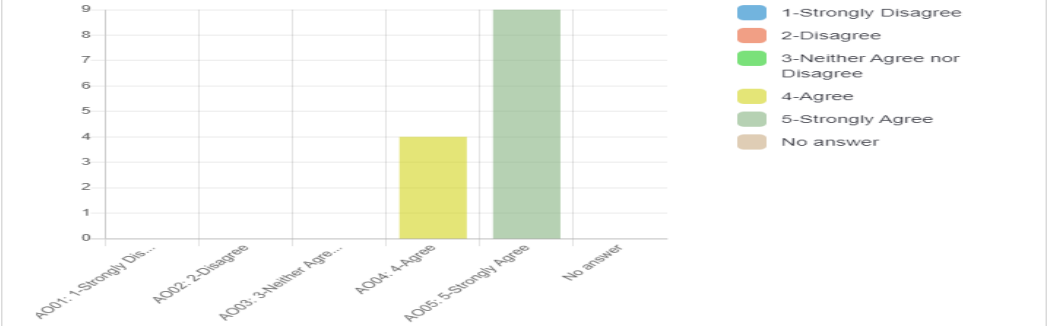


Figure 17-12: Survey Q9 Results

It is evident that 69.23% strongly agreed, whilst 30.77% agreed.

17.6 Discussion

The online survey aimed to gather insights on the importance of data integrity to ensure the quality of address information in MHFL. Participants provided inputs on the Survey Questions (SQ), highlighting the need for continuous data integrity measures in the fast-evolving healthcare system to protect health information. The results align with the literature review, as participants responded positively to the importance of data integrity in ensuring the quality of address information for MHFL.

> *SQ1. Data integrity can ensure that the address information recorded in the MHFL is accurate for generating reliable reports and analytics for the decision-making process at various levels of healthcare management.*

Data integrity is crucial in maintaining information's reliability, accuracy, and usefulness for generating reliable reports and analytics in healthcare management (Duggineni, 2023). One participant shared the same sentiments and stated:

> *Data integrity guarantees that produced reports and analytics in healthcare systems are true and trustworthy. Healthcare businesses can make better decisions, allocate resources more effectively, promote quality improvement programs, and successfully comply with regulations by adherence to data integrity principles.*

In a similar view where the users are at the centre of data integrity, a participant mentioned that *"Users must be exact for MHFL to produce trustworthy reports and facility information. MHFL users are responsible for guaranteeing the accuracy, completeness, and long-term quality of facility information".* Another participant states: *"In data, it is always said that garbage in equals garbage out. When data isn't validated and cleaned, it won't give accurate and reliable results in analytics reporting, predictions and forecasting".* Healthcare professionals can make more informed decisions, improve service delivery, and improve population health outcomes by adhering to data integrity standards and best practices.

> *SQ2. Accurate addresses in the MHFL can assist in easily locating healthcare facilities and ensuring timely access to the medical care of patients.*

Accurate addresses facilitate precise facility location for patients, medical professionals, and emergency personnel. Accurate address information in the MHFL guarantees that people can find the closest healthcare facility, no matter where they are. This includes hospitals, clinics, and primary care centres. *"Precise addresses allow emergency personnel to find and contact patients who require immediate medical assistance in an emergency, perhaps saving lives".* One participant said: *"Precise addresses guarantee that patients receive the care they require at the appropriate time, and location, which enhances the effectiveness, safety and efficacy of healthcare delivery"*. To

properly plan and organise healthcare services, healthcare professionals depend on reliable address data. Decision-makers can pinpoint locations where healthcare access is lacking, strategically deploy resources, and enhance service delivery to fulfil the populace's demands by mapping healthcare facilities and examining service coverage areas. It was reported that *"Vaccination site or Facility information should be accurate and reliable for vaccinees to locate facility should they want to go for vaccinations"*. Another stated: *"The correctness of facility address helps in Equitable Distribution and Inventory Control, ensuring that vaccines and medicines are distributed and reaching facilities on time and are administered equitably across population demographics and rural/urban areas"*. Accurate address information makes healthcare facilities more easily identified and accessible, contributing to a more responsive, egalitarian, and patient-centred healthcare system.

SQ3. Accurate address information reduces the likelihood of fraudulent claims or improper use of healthcare services, safeguarding the integrity of the healthcare system.

With accurate address information, verifying the identity of patients seeking healthcare services is easier. If healthcare professionals verify the patient's address and verify the patient is real, they can significantly reduce the possibility of identity theft and impersonation. A participant stated: *"Precise addresses can be utilised in patient authentication procedures, particularly when transmitting or accessing private medical data"*. Accurate address information assists in verifying the legitimacy of claims submitted for reimbursement or payment. Cross-referencing patient addresses with other demographic information can assist healthcare organisations in detecting discrepancies or inconsistencies, such as billing for services not rendered or billing for fictitious patients. It was mentioned that *"Accurate and reliable data, including precise addresses, can contribute to detecting and preventing fraudulent activities within the healthcare system. It helps verify the legitimacy of claims and ensures that healthcare services are appropriately utilised. Address information can be a crucial factor in identity verification and tracking the utilisation of services, making it more difficult for individuals to engage in fraudulent activities"*. Similarly, another response *reported, "By using the right facility address, we can ensure that corruption-related issues like tardiness, unauthorised payments, fraud, resource mismanagement, and supply theft are properly dealt with and that the right measures are taken to prevent them from happening again"*. Hawayek and AbouElKhir (2023) posit using blockchain technology, which maintains data integrity, as a digital health solution for addressing concerns with medical claims and challenges connected to paying fraudulent claims.

SQ4. Reliable address information can enable healthcare providers and policymakers to effectively plan and deliver healthcare services.

Reliable address information is essential for healthcare providers and policymakers to effectively plan and deliver healthcare services, target interventions, promote health equity, and make evidence-based decisions that improve health outcomes and advance population health." *Accurate*

address information is essential for proper healthcare planning and delivery. It allows healthcare providers and policymakers to understand the geographical distribution of the population, identify areas with specific healthcare needs, and allocate resources accordingly. This information is crucial for planning the location of healthcare facilities, implementing targeted public health interventions, and ensuring equitable access to healthcare services". Another sentiment mentioned: *"To ensure that the government maintains strict control over inventory while boosting throughput, reliable address information is crucial for the high volume and equitable distribution of pharmaceuticals and health services. This will ultimately result in the concentration of these services and supplies in highly populated and affluent areas"*.

> *SQ5. Reliable address information can enable policymakers to identify areas of inadequate healthcare infrastructure and allocate resources accordingly to address gaps and improve access to care.*

A participant stated:

> *Policymakers can better identify and manage healthcare access inequality by using accurate address information, which will ultimately improve healthcare outcomes for all members of society. Policymakers can evaluate the healthcare needs of various areas by considering variables like population density, demographics, and the availability of healthcare resources, provided they have precise address information. This aids in determining the areas with the greatest need for healthcare services as well as coverage gaps.*

Providing reliable address information enables policymakers to identify existing healthcare services and facilities, including hospitals, clinics, pharmacies, and speciality care centres. Policymakers can identify areas with insufficient access to healthcare services by visualising the distribution of healthcare infrastructure across geographical regions. Policymakers can use geospatial analysis to assess healthcare access and utilisation disparities. Using address information in conjunction with demographic information, socioeconomic indicators, and health outcomes, policymakers can identify underserved communities, rural areas, or urban neighbourhoods that do not have ready access to healthcare. In this manner, policymakers can prioritise interventions and healthcare initiatives based on identified needs and gaps in healthcare infrastructure. By focusing on areas that are most in need, policymakers can maximise the impact of interventions, reduce disparities in healthcare access, and improve health outcomes for vulnerable populations (Thomson et al., 2018). Additionally, reliable address information can be used to monitor and evaluate the effectiveness of healthcare infrastructure investments and initiatives to improve access to healthcare resources. To assess the impacts of interventions on healthcare service availability, utilisation rates, and health outcomes over time, policymakers can use data-driven decisions to adjust resource allocation strategies as necessary (Wagenaar et al., 2017).

SQ6. Data integrity can safeguard patient safety by ensuring that accurate address information is available when needed.

The accuracy of address information enables healthcare providers to locate patients quickly and efficiently when they require medical care. Having reliable data allows healthcare services to be accessed promptly, reducing the risk of delays that could compromise patient safety (Najeeb, 2021). This is true whether it is an emergency response, appointment scheduling, or follow-up care. One participant reported, "*Incorrect address information in the MHFL can lead to patient safety concerns, such as delays in emergency response time or difficulties locating healthcare facilities. Data integrity safeguards patient safety by ensuring that accurate address information is available when needed".* While another participant reported,

> *Accurate address information is critical in various healthcare scenarios, including emergencies, hospital admission, and follow-up care. If the address data is inaccurate or outdated, it could lead to delays, miscommunication, or difficulty reaching patients, especially in urgent situations. This could potentially compromise patient safety.*

Accurate address information is essential for public health interventions to prevent and control infectious diseases, manage outbreaks, and monitor population health trends. Similarly, *"Precise address information helps with public health monitoring by enabling officials to follow disease outbreaks, keep an eye on health patterns, and pinpoint populations that are high risk".* Public health professionals can maintain community safety and health by preventing the spread of diseases, identifying hotspots, and precisely tracking and mapping cases based on address data. *"Implementing focused efforts to stop the spread of illnesses and safeguard community health requires this knowledge".*

SQ7. Data integrity enables data analysis and research of address information for researchers to study disease patterns, assess healthcare disparities and evaluate the effectiveness of healthcare interventions.

Data integrity is essential for enabling data analysis and research of information in public health and healthcare research. By maintaining the integrity of address data, researchers can conduct rigorous studies, generate actionable insights, and inform evidence-based strategies for improving population health and addressing health disparities (Knepper et al., 2019; Bernardi et al., 2023). Strong research and analysis of address data -which are necessary for comprehending illness trends, evaluating therapies, analysing healthcare inequalities, and guiding evidence-based healthcare policies and practices – are made possible by data integrity. Data integrity guarantees the consistency and dependability of address information, offering a solid basis for data analysis. To better understand how diseases move across populations, researchers can confidently evaluate address data to detect spatial patterns of disease incidence, prevalence, and dispersion.

SQ8. Ensuring data integrity in the MHFL can assist healthcare organisations in meeting regulatory requirements and avoid penalties associated with non-compliance.

Regulatory bodies can conduct audits, inspections, or investigations to assess healthcare regulations and standards compliance. Healthcare organisations must provide accurate reports and submissions, meet reporting deadlines, and complete regulatory responsibilities without errors or discrepancies (Edwards, 2019; Smyth, Parker, and Sharif, 2020). Maintaining accurate, complete, and standardised data in the MHFL and demonstrating compliance with regulatory requirements related to data quality and consistency. Healthcare professionals can make well-informed decisions, efficiently coordinate patient care, and ensure patients receive treatments from accredited, licensed, and compliant healthcare facilities using accurate and reliable facility information in MHFL. One participant said,

> *By prioritising data integrity, healthcare organisations can establish robust systems and processes for managing patient information, meeting regulatory requirements, and mitigating the risk of non-compliance penalties. This protects patients' privacy and security and helps organisations maintain their reputation and financial viability in an increasingly regulated healthcare environment.*

Another participant reported:

> *SAHPRA (South African Health Products Regulatory Authority) depends on reliable data for monitoring and regulating pharmaceuticals and medical devices. Erroneous information can jeopardise patient safety and make regulatory oversight more difficult. By integrating with the SVS system, MFHL guarantees that the public and private sectors' crucial Covid-19-related medication supply is handled with integrity and in a straightforward, open manner.*

Healthcare institutions that violate regulatory regulations may face financial and legal repercussions, such as fines, penalties, lawsuits, or accreditation loss. Maintaining data integrity in the MHFL reduces these risks by offering precise records, proof of compliance, and audit trails to back up requests from authorities or court cases.

SQ9. Maintaining data integrity in the MHFL enhances trust and confidence in the healthcare system as patients, users, and stakeholders expect reliable information to be available when making healthcare-related decisions, and data integrity ensures that this expectation is met.

Data integrity includes safeguarding the privacy and confidentiality of address information stored in the MHFL. Healthcare organisations can demonstrate their commitment to protecting

sensitive information and meeting quality, safety, and compliance standards by employing strong data integrity safeguards. A participant stated, *"Data quality control is critical for any company that shares, processes, or analyses data. Healthcare providers who work with patients' medical records daily are aware of this. Thus, MHFL provides stringent guidelines and safeguards through data governance to preserve the data"*. Data integrity also fosters transparency and accountability in the healthcare system by allowing users to access information about facilities, services, and performance measures. This transparency enables patients to make educated decisions and holds healthcare professionals accountable for providing high-quality care. Overall, data integrity is critical in a trust-based healthcare system. One participant agreed with the statement and reported,

> *In the healthcare system, data integrity promotes accountability and transparency. Patients and other stakeholders are more likely to have faith in the choices made by lawmakers and healthcare professionals when they believe that the data used to make healthcare decisions is reliable and comprehensive. This openness encourages confidence in the overall integrity of the healthcare system.*

Data integrity is crucial for addressing information quality, reliability, and usability in the Master Health Facility List. It supports effective healthcare planning, patient navigation, emergency response, data integration, trust, transparency, and regulatory compliance, ultimately improving healthcare access and outcomes.

17.7 Recommendations

The recommended sections attempt to assist the NDoH with managing the address information inaccuracy that the Facility Representatives populate in the MHFL system. The World Health Organisation (2024), defines recommendations as actions to be taken in response to the findings of a report. Thus, recommendations 1 to 6 can take effect as and when the NDoH wants to implement them, but recommendations 7 to11 can be applied in the future as MHFL advances in technology.

1. Facility Representatives must be accountable for the address information they input into the MHFL.
2. Facility Representatives must make sure the address information is accurate and reliable.
3. Facility Representatives appointed for facilities must be based in the facilities so that they know the address of their facilities.
4. When street names or numbers are unavailable, Facility Representatives must use landmarks to indicate the facility's location.
5. The NDoH must prepare a memorandum of agreement (MOU) that all organisations wishing to be in the MHFL must sign. This MOU must state the importance of data

integrity to ensure the quality of address information in the MHFL, and the Facility Representatives must always sign it as a declaration to input correct address information in the MHFL.

6. Special training for facility representatives must be designed to assist them in providing accurate address information and emphasising its relevance.
7. There should be an SOP document that is shared with the end users of the MHFL to ensure data integrity is maintained, as (Khela et al., 2024) posits that the absence of consistent documentation strategies among healthcare staff can result in new errors that can be replicated in following notes.
8. As the MHFL evolves, the system should impose features that allow address information to be validated as the Facility Representatives input the address information.
9. The MHFL system should not allow facility representatives to update address information that the data cleaning team has already verified; if a need arises to make address adjustments in such a facility, the facility representatives must request the necessary change via HISSUPPORT.
10. Validation rules in the MHFL must be improved to force users to enter the correct address in the right subcategory. If an area has been designated as a suburb but is a town, the system should return an error for users to capture correctly.
11. The MHFL system should not allow duplicate area identifications; each area should be assigned to just one subcategory.

17.8 Conclusion

Finally, this chapter examines data quality and integrity and addresses the literature essential to this study's outcome. Facility Representatives are end users of the MHFL and are responsible for entering the address information of the health facilities in the MHFL. As observed from the literature findings and the recommendation sections, it's necessary to ensure that this address information is of quality and maintain the correct data integrity to ensure reliability and accuracy. Furthermore, The MHFL aligns with the digital health workforce, driving strategic economic development intervention that addresses the inadequate human resource component. These end users are trained to enter the accurate address information in the MHFL, and further recommendations are provided to have special training that focuses only on address information in the MHFL, which addresses the *Inadequate Human Resource* problem facing the South African health systems. However, there is still a long way to go in ensuring that all Facility Representatives of the MHFL take accountability for ensuring accurate address information. System enhancements can only occur as the MHFL technically advances and develops, address information can be accurate today. Measures can be put in place to ensure this happens, so this chapter advocates for the importance of data integrity in ensuring the quality of address information in the MHFL.

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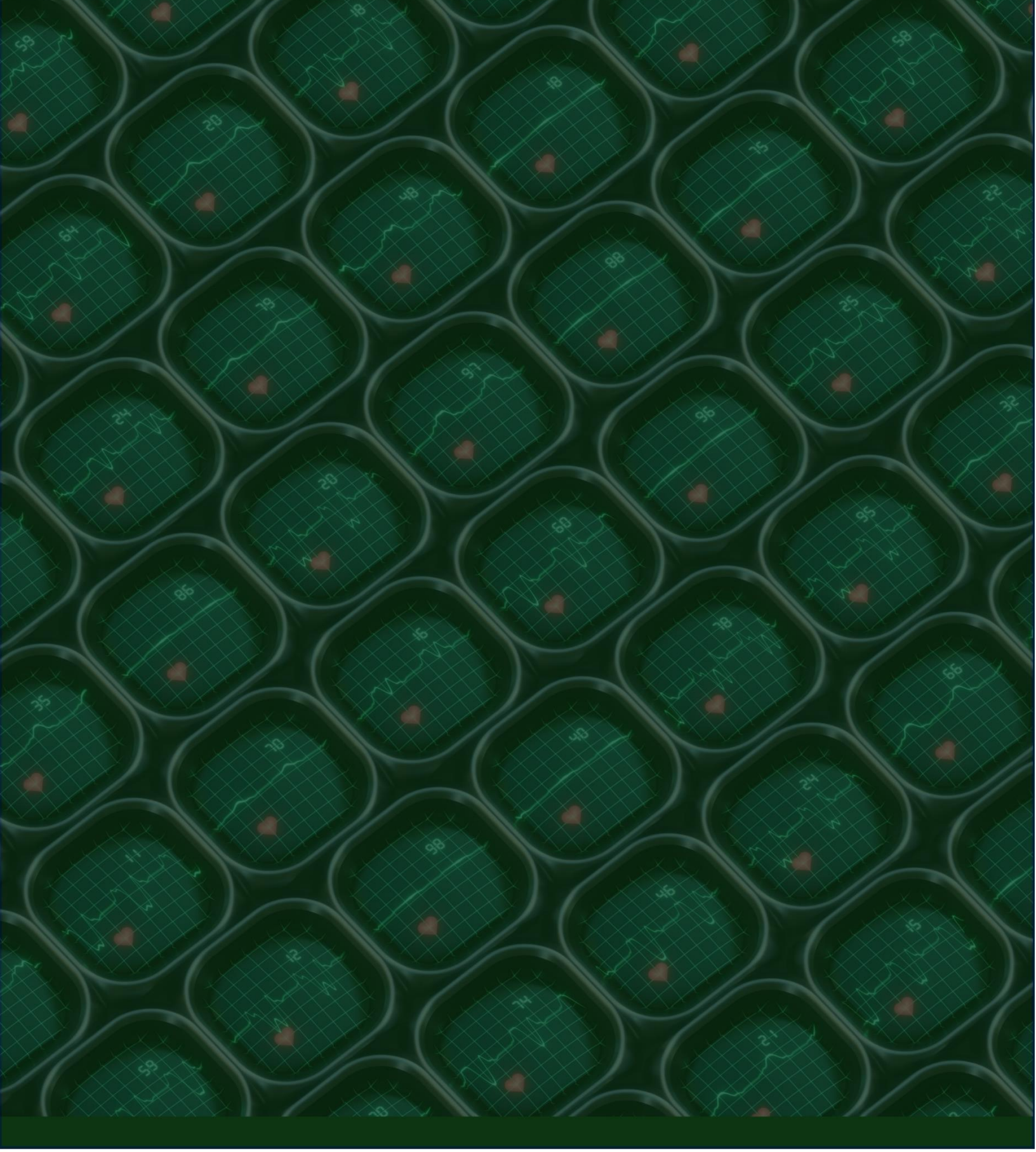

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