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A Retrospective Cohort Study to Determine COVID-19 Mortality, Survival Probability and Risk Factors Among Children in a South African Province

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Abstract

Numerous factors contributed to coronavirus 2019 (COVID-19) disease recovery and death rates. In many countries, socioeconomics, morbidities, the experience of symptoms and access to healthcare services are major contributors to recovery and death rates. A retrospective cohort study was conducted to determine the morbidity, mortality, survival probability, and risk factors associated with COVID-19 among children in the Free State province, South Africa. A total of 846 patients' records were used in the study. Using SPSS version 28 software, survival probability was determined using Kaplan–Meier estimation curves and Cox regression was used to determine the effect of sociodemographics and clinical manifestation information on time of death. The COVID-19 mortality rate was 13.12% in our study. There were more female patients (60%) than male patients (40%). In total, 71 patients had two or more morbidities, while 414 patients were asymptomatic. Patients between 5 and 18 years old were at twice the risk of dying of COVID-19, and male children were at a higher risk as well. Having more than one symptom was also a risk for dying in this study. Severe COVID-19 is attributed to numerous factors, and these are closely associated with surrounding environments and public health systems. The findings are important for the clinical management of similar diseases and circumstances in the future.

Keywords: coronavirus disease 2019; COVID-19; morbidity; mortality; survival probability; children; risk factors

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1. Introduction

Coronavirus disease 2019 (COVID-19) is a global phenomenon that has impacted communities (especially poor communities) in various ways. It originated in China and was declared a pandemic on 11 March 2020 by the World Health Organisation [WHO] [1,2]. According to the WHO COVID-19 dashboard in late 2025, there were 779,051,482 reported cases worldwide and 9,589,553 cases with 175,532 deaths in the African region [3]. It is estimated that 7% infected with COVID-19 were hospitalized and 33% required intensive care [4,5]. In the United States, COVID-19 deaths were ranked eighth in all causes of death in 2022 [6].

The severity of COVID-19 varies significantly, encompassing a range of outcomes from mild to severe, including fatal consequences [7,8]. Patients with underlying or pre-existing

conditions (comorbidities) prior to infection, especially chronic conditions such as immunosuppression, diabetes, obesity and heart failure, are adversely affected [7,8]. The most common underlying conditions in children diagnosed with COVID-19 are cardiovascular conditions, diabetes, cancer, malignancies and obesity [8,9]. These children were at a higher risk of severity of the disease, with outcomes ranging from hospitalization in intensive care units to fatality [10]. Some of these commodities are believed to have significantly increased the risk of severe long COVID, especially cardiovascular and neurological disease [11–14].

COVID-19 patients exhibit a diverse clinical spectrum, encompassing asymptomatic cases (the absence of symptoms), pre-symptomatic presentations (initial symptoms), and highly symptomatic cases (manifesting numerous and severe symptoms) [15]. The World Health Organisation and other scientists reported that common signs and symptoms among children were pneumonia, headache, sore throat, fever, difficulty breathing, cough, trouble breathing, abdominal pain, nausea, diarrhea, vomiting, the loss of smell and taste, malaise, tiredness, weakness or aching muscles and joints and dyspnea [16,17]. The literature indicates that these symptoms are prevalent not only in COVID-19 but also in long COVID, which is characterized as the later phase of the infection [18]. During the COVID-19 pandemic, younger patients, particularly children, exhibited, on average, milder symptoms in comparison to older patients, such as adults [19]. However, the children who experienced severe (more) symptoms were at risk of being hospitalized and dying due to COVID-19 [20,21]. Lastly, COVID-19 is associated with complications affecting multiple bodily systems, including the respiratory, renal, gastrointestinal, hepatic, central nervous, and cardiovascular systems [7,8].

COVID-19 affects different populations and age groups differently, especially those who are from resource-deprived areas [22,23]. Rural-dominated areas are the most affected [24]. There is a paucity of research and information from these regions relating to the severity, mortality, morbidity, and survival rates of COVID-19, particularly in Sub-Saharan regions, including South Africa. A comprehensive understanding of the COVID-19 phenomenon is imperative, given the ongoing transmission of the virus and the emerging concerns regarding long COVID. Therefore, this study aims to evaluate COVID-19 morbidity, mortality, survival probability, and associated risk factors among children residing in predominantly rural areas of South Africa.

2. Materials and Methods

2.1. Study Design, Setting and Participants

A retrospective observational cohort study was conducted using secondary data from the Free State Province Department of Health (FSDoH). The Free State province of South Africa, which is predominantly rural, comprises one metropolitan municipality, Mangaung, and four districts: Fezile Dabi, Lejweleputswa, Thabo Mofutsanyana, and Xhariep. As of 2022, the province had an estimated total population of 2.9 million, which included approximately 513,798 children aged 0–9 years and 535,247 individuals aged 10–19 years [25]. In November 2021, it was reported that the Free State province had the fifth highest number of COVID-19 cases in South Africa, with a cumulative total of 163,929 cases since the onset of the pandemic in March 2020 [26]. The study's participants were children aged between 0 and 18 years who were hospitalized following a clinical diagnosis of COVID-19 (i.e., tested positive). Inclusion criteria for this study were limited to children diagnosed between 1 March 2020 and 30 November 2021.

2.2. Sampling

Data for this study were gathered utilizing a record review guide to extract secondary data from the FSDoH COVID-19 database. The collected data encompassed sociodemo-

graphic information, patient medical history (including pre-existing conditions reported before a COVID-19 diagnosis), details regarding the period of infection, and health outcomes (either died or survived). Additionally, clinical information regarding the signs and symptoms reported by patients was included. The anonymization of the data occurred immediately upon collection by the institution, and each record was assigned a unique identifier. Initial data collection was conducted by provincial surveillance officers across various districts.

2.3. Data Collection and Management

Data for this study were gathered utilizing a record review guide to extract secondary data from the FSDoH COVID-19 database. This study initially collected 11,901 records. Subsequently, records pertaining to individuals above 18 years of age were excluded, resulting in a total of 1043 remaining records. Thereafter, records with any missing data were removed, leaving a final total of 846 records that were included in the study.

The first author (LAT) acquired, cleaned, and prepared the raw data from the FSDoH, while TPM validated the data for subsequent analysis. Additionally, MCM oversaw and supervised the entire data processing workflow, from collection to analysis.

2.4. Sociodemographics and Clinical Manifestation in the Study

For this study, the following sociodemographic variables were categorized: gender (female = 1/male = 2), age (7 days or less, 8–14 days, 15–21 days, 22–28 days and 29 or more days) and number of days (refers to days from hospital admission) before the health outcome (7 days or less = 1/8–14 days = 2/15–21 days = 3/22–28 days = 4/29 and more days = 5). The morbidities (underlying conditions) were immune-compromised (no = 0/yes = 1), cardiovascular condition (no = 0/yes = 1), lung-related conditions (no = 0/yes = 1), diabetes (no = 0/yes = 1), and gastrointestinal conditions (no = 0/yes = 1). Thereafter, the number of morbidities per patient was determined, and the following variable was created: "the number of morbidities" (no morbidities, 1 morbidity and $\geq$2 morbidities = 3).

The clinical information was used for the following variables: "symptoms" (did the patient develop signs and symptoms associated with COVID-19? (no = 0/yes = 1). Collected signs and symptoms were described and arranged as follows: fever and chills (no = 0/yes = 1), headache (no = 0/yes = 1), runny nose and congestion (no = 0/yes = 1), cough (no = 0/yes = 1), new or loss of taste and smell (no = 0/yes = 1), muscular pain (no = 0/yes = 1), nausea or vomiting (no = 0/yes = 1), fatigue (no = 0/yes = 1), shortness of breath (no = 0/yes = 1), and sore throat (no = 0/yes = 1). The number of symptoms (no symptom = 1, 1–3 symptoms or $\geq$4 symptoms) was developed after counting the number of signs and symptoms experienced by a patient.

2.5. Study Outcome

The study outcome variable was a health outcome categorized into survived (discharged, cured and/or transferred to a government treatment facility) and time of death (died). Time of death was an outcome of interest in this study (coded as 1 for analysis purposes). At the same time, survived was coded as a "0" in the current study. The health outcome was a dependent variable in this study.

2.6. Data Analysis

Data were analyzed using IBM SPSS version 28 software. Descriptive statistics for continuous variables were presented as means and standard deviations (SDs), while categorical variables were presented as frequencies and percentages. The log-rank test was used to determine the statistical differences between those who survived and those who

died within the individual variables of the study, with a *p*-value set at 0.05 for statistical significance. Kaplan–Meier survival analysis was conducted to compare mortality rates among males and females, different age groups, the number of morbidities, the number of symptoms, and individuals with or without cardiovascular or diabetes conditions. Lastly, risk factors associated with COVID-19 mortality in the study were determined using Cox regression analysis. The model was first fitted with time (the number of days before the event [death]) and the status, defined as the health outcome (died = 1). We conducted bivariate Cox regression analysis for all individual participants' characteristics. In the final model, a multivariate Cox regression analysis was performed using the Wald backward elimination stepwise method to identify risk factors associated with the time of death due to COVID-19, including all variables in the final model. The *p*-value was set at 0.05 to indicate a statistical association between risk factors and time of death.

2.7. Ethical Considerations

The study obtained ethical clearance from the University of Johannesburg, Faculty of Health Sciences, Research Ethics Committee (REC-347-2020). The Free State Department of Health (13 December 2021) also permitted the researchers to conduct the study and access the data.

3. Results

3.1. Study Participant Characteristics

This study comprised 846 patients aged from less than 1 year to 18 years, with a mean age of 10.6 years (standard deviation = 6.3), as shown in Table 1. The majority of participants were aged 15–18 years (n = 264, 31%), while 24% (n = 199) belonged to the youngest age group. There were more female patients (n = 505; 60%) than male patients (n = 341; 40%) in the study. Most participants did not have underlying morbidities (n = 596, 70%) at the time of their COVID-19 diagnosis. However, 21% (n = 178) reported experiencing one or more morbidities during the diagnosis; the types of morbidities are discussed in the subsequent section. The majority of participants experienced either 1–3 symptoms (n = 416, 46%) or 4 or more symptoms (n = 64, 7%). Conversely, 49% (n = 414) of participants did not experience any symptoms during this period. Most participants either survived or did not survive within 7 days of diagnosis.

Table 1. Study participant characteristics.

Variable	Frequency n	%
Age		
0–4 years old	199	24%
5–9 years old	143	17%
10–14 years old	240	28%
15–18 years old	264	31%
Gender		
Female	505	60%
Male	341	40%
Number of morbidities		
No morbidities	596	70%
1 morbidity	178	21%
≥2 morbidities	72	9%

Table 1. *Cont.*

Variable	Frequency n	%
Number of signs and symptoms		
No symptom	414	49%
1–3 symptoms	384	45%
≥4 symptoms	48	6%
Number of days before health outcome		
7 days or less	432	51%
8–14 days	310	37%
15–21 days	55	7%
22–28 days	19	2%
29 and more days	30	6%

3.2. Pediatric Patients with COVID-19 Clinical Manifestation in This Study

There were several participants who reported pre-existing morbidities prior to their diagnosis of COVID-19. Among the cohort, there were 38 pediatric patients with compromised immune systems, resulting in a mortality rate of 15.02 cases per 1000 child-days. This study identified fatalities among children with cardiovascular conditions (34 cases) and lung-related conditions (4 cases). Additionally, children with diabetes exhibited a high mortality rate of 33.92 per 1000 children-days, with 68 out of 99 patients surviving. Furthermore, 25 patients (3%) reported having gastrointestinal conditions before their COVID-19 diagnosis. A significant difference was observed in mortality rates between patients with cardiovascular conditions and diabetes, as shown in Table 2.

Table 2. Description and comparison of morbidities reported in the study.

Morbidity		Total n (%)	Survived n (%)	Died n (%)	Mortality Rate Per 1000 Children (in Days)	*p*-Value [a]
Immuno-compromised	No	808 (96%)	702 (96%)	106 (96%)	12.52	0.67
	Yes	38 (4%)	33 (4%)	5 (4%)	15.02	
Cardiovascular condition	No	704 (83%)	627 (85%)	77 (69%)	11.02	<0.01 *
	Yes	142 (17%)	108 (15%)	34 (31%)	21.58	
Lung-related condition	No	831 (98%)	724 (99%)	107 (96%)	12.64	0.27
	Yes	15 (2%)	11(1%)	4 (4%)	22.39	
Diabetes	No	747 (88%)	667 (91%)	80 (72%)	10.25	<0.01 *
	Yes	99 (12%)	68 (9%)	31 (28%)	33.92	
Gastrointestinal conditions	No	821 (97%)	713 (97%)	108 (97%)	12.82	0.95
	Yes	25 (3%)	22 (3%)	3 (3%)	12.93	

[a] Log-rank test, *p*-value was set at 0.05 for statistical significance, * shows statistical significance.

Patients in this study experienced numerous symptoms associated with COVID-19. There were 105 (12%) patients that experienced fever and chills, with 10 dying at a mortality rate of 9.68 cases per 1000 children in days. The mortality rate was high among children that experienced fatigue and shortness of breath with 38.65 and 28.43, respectively. Lastly there was a significant difference among those that survived and died between those who had fatigue and shortness of breath. A detailed presentation of signs and symptoms is displayed in Table 3.

Table 3. Description and comparison of signs and symptoms reported in the study.

Morbidity		Total n (%)	Survived n (%)	Died n (%)	Mortality Rate Per 1000 Children (in Days)	*p*-Value [a]
Fever and chills	No	741 (88%)	640 (87%)	101 (91%)	13.28	0.40
	Yes	105 (12%)	95 (13%)	10 (9%)	9.68	
Headache	No	722 (85%)	626 (85%)	96 (86%)	13.36	0.36
	Yes	124 (15%)	109 (15%)	15 (14%)	9.58	
Runny nose and congestion	No	787 (93%)	686 (93%)	101 (91%)	12.63	0.95
	Yes	59 (7%)	49 (7%)	10 (9%)	14.98	
Cough	No	583 (69%)	515 (70%)	68 (61%)	11.45	0.12
	Yes	263 (31%)	220 (30%)	43 (39%)	15.72	
New/loss of taste and smell	No	789 (93%)	682 (93%)	104 (94%)	12.91	0.57
	Yes	60 (7%)	7 (6%)	3 (3%)	11.67	
Muscular pain	No	783 (93%)	682 (93%)	101 (91%)	12.60	0.58
	Yes	63 (7%)	53 (7%)	10 (9%)	15.36	
Nausea/vomiting	No	830 (98%)	721 (98%)	109 (98%)	12.74	0.65
	Yes	16 (2%)	14(2%)	2 (2%)	17.70	
Fatigue	No	780 (93%)	696 (95%)	93 (84%)	11.27	<0.01 *
	Yes	57 (7%)	39 (5%)	18 (16%)	38.65	
Shortness of breath	No	710 (84%)	639 (87%)	71 (64%)	10.40	<0.01 *
	Yes	136 (16%)	96 (13%)	40 (36%)	28.43	
Sore throat	No	759 (90%)	658 (90%)	101 (91%)	12.85	0.98
	Yes	87 (10%)	77 (10%)	10 (9%)	12.55	

[a] Log-rank test, *p*-value was set at 0.05 for statistical significance, * shows statistical significance.

3.3. The Mortality Rate According to Characteristics and Survival Probability Among Pediatric Patients in This Study

In total, 111 children died from COVID-19 in this study at a mortality rate of 12.82 cases per 1000 children in days. Table 4 presents the mortality rate according to patient characteristics. Most were aged between 15 and 18 years old (n = 55, 44%) with a mortality rate of 15.46 cases per 1000 children in days and were female (n = 64, 51%) with a mortality rate of 10.80 cases per 1000 children in days, yet the mortality rate was low compared to male patients (17.78 cases per 1000 children in days). The following comparison showed a significant difference between those who survived and died: age ($p < 0.01$), the number of morbidities ($p < 0.01$), the number of signs and symptoms ($p < 0.01$), and the number of days before the outcome ($p < 0.01$). Gender did not show a significant difference ($p = 0.09$).

The Kaplan–Meier survival estimates (as shown in Figure 1) showed that male children took longer (2 times more likely) to recover compared to female children in the study and there was no statistical difference ($p = 0.09$) between male and female children. This was similar to the signs-and-symptoms variable; there was no statistical difference in survival curves ($p = 0.90$). The Kaplan–Meier log-rank test showed statistical differences in the survival curves for the following variables: age ($p < 0.01$), morbidities ($p < 0.01$), cardiovascular disease ($p < 0.01$), and diabetes ($p < 0.01$).

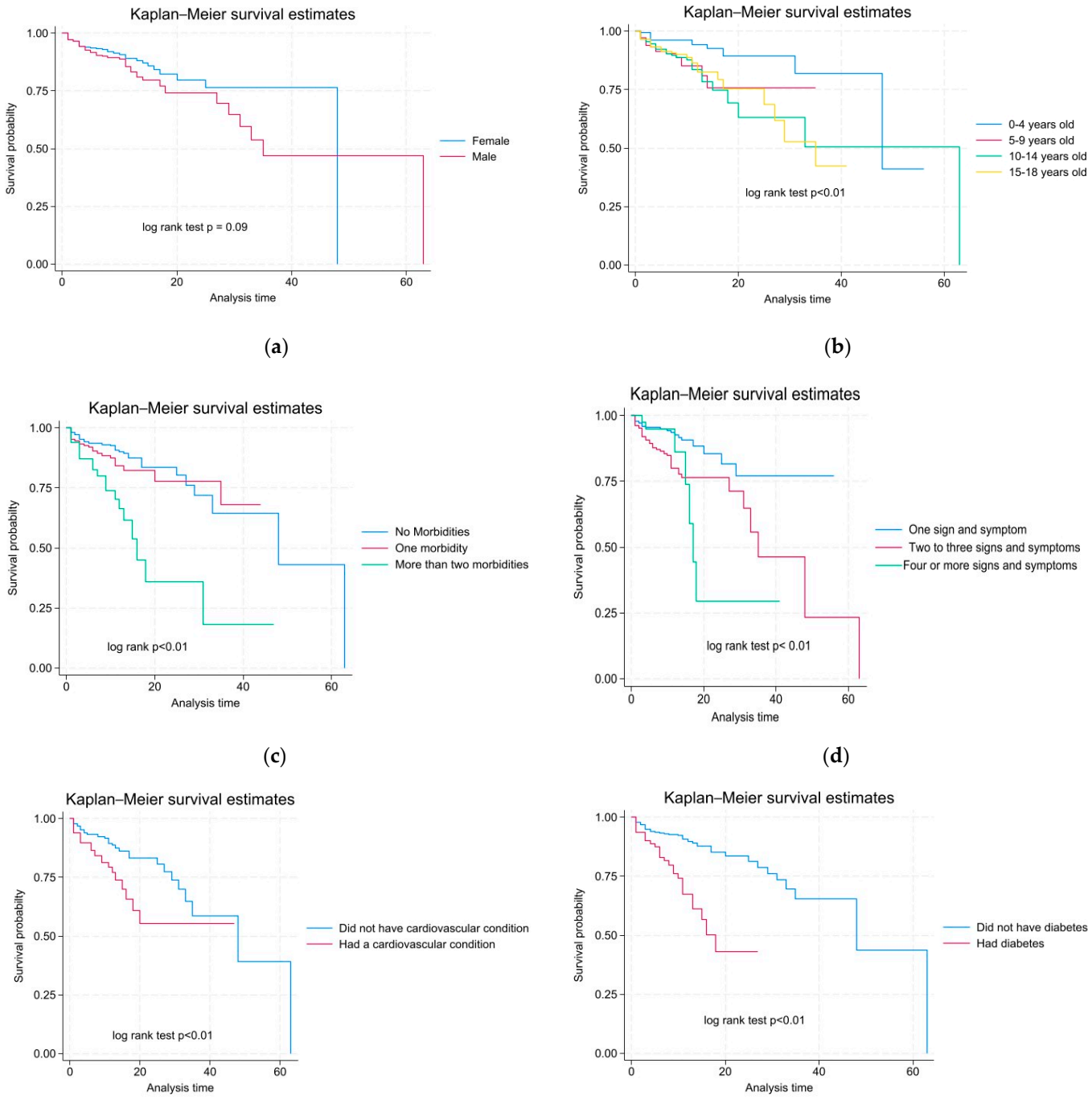

Figure 1. Survival probability according to risk factors and morbidities. (**a**) Survival probability based on gender; (**b**) survival probability based on age groups; (**c**) survival probability based on patients that reported no morbidities, one morbidity and two or more morbidities; (**d**) survival probability based on patients who were asymptomatic or experienced 1–3 symptoms or 4 or more symptoms; (**e**) survival probability based on patients with and without cardiovascular disease; (**f**) survival probability based on patients with and without diabetes.

Table 4. Mortality rate and comparison of pediatric patients' characteristics.

Patient Characteristics	Total n (%)	Survived n (%)	Died n (%)	Mortality Rate Per 1000 Children (in Days)	*p*-Value [a]
Age					
0–4 years old	199 (22%)	186 (24%)	13 (10%)	5.73	<0.01
5–9 years old	143 (16%)	123 (16%)	20 (16%)	15.83	
10–14 years old	240 (26%)	202 (26%)	38 (30%)	16.68	
15–18 years old	332 (35%)	277 (35%)	55 (44%)	15.46	
Gender					
Female	552 (60%)	488 (62%)	64 (51%)	10.80	0.09
Male	362 (40%)	300 (38%)	62 (49%)	15.78	
Number of morbidities					
No morbidities	662 (72%)	594 (75%)	68 (54%)	10.11	<0.01
1 morbidity	181 (20%)	147 (19%)	34 (27%)	13.27	
≥2 morbidities	71(8%)	47 (6%)	24 (19%)	35.97	
Number of signs and symptoms					
No symptom	434 (47%)	403 (51%)	31 (25%)	7.23	<0.01
1–3 symptoms	416 (46%)	334 (42%)	82 (65%)	18.76	
≥4 symptoms	64 (7%)	51 (6%)	13 (10%)	17.50	
Number of days before outcome					
7 days or less	432 (51%)	356 (48%)	76 (68%)	39.92	<0.01
8–14 days	310 (37%)	289 (39%)	21 (19%)	6.27	
15–21 days	55 (7%)	49 (7%)	6 (5%)	6.51	
22–28 days	19 (2%)	17 (2%)	2 (2%)	4.26	
29 or days	30 (4%)	24 (3%)	6 (5%)	5.40	

[a] Log-rank test, *p*-value was set at 0.05 for statistical significance.

3.4. Risk Factors of Time to Death in the Current Study

In the bivariate cox regression (shown in Table A1), time of death was associated with the following age groups, [5–9 years old, $p = 0.01$; 10–14 years old, $p < 0.01$; 15–18 years old, $p < 0.01$)], being a male ($p = 0.05$), having two or more morbidities ($p < 0.01$), experiencing one to three signs and symptoms and more than four signs ($p < 0.01$) and symptoms ($p = 0.01$), having a cardiovascular condition ($p < 0.01$) and having diabetes ($p < 0.01$). Also, it was associated with having shown or experienced the following signs and symptoms: fatigue ($p < 0.01$) and shortness of breath ($p < 0.01$).

In the final model (multivariate Cox regression backward stepwise analysis, as shown in Table 5), older children (5–9 years old [aHR: 2.09; 95%CI: 1.01–4.31], 10–14 years old [aHR: 2.24; 95%CI: 1.15–4.37] and 15–18 years old [aHR: 2.25; 95%CI: 1.17–4.35]) were at double the risk of dying in the study. Male children in the study were at a higher risk (aHR: 1.45; 95%CI: 1.00–2.18) of dying. Those that experienced 1–3 (aHR: 3.06; 95%CI: 1.51–6.44) or 4 or more (aHR: 6.40; 95%CI: 1.45–28.18) signs and symptoms were at a much higher risk of dying, three and six times, respectively. Children who experienced fever and/or chills (aHR: 0.37; 95% CI: 0.18–0.77) and headache (aHR: 0.50; 95%CI: 0.26–0.95) were at a lower risk of COVID-19 mortality.

Table 5. Final model: multivariate Cox regression analysis for significant risk factors for time of death in the study.

Factors		Adjusted HR	*p*-Value	95% Confidence Interval
Age	5–9 years old	2.09	0.05 *	1.01–4.31
	10–14 years old	2.24	0.02 *	1.15–4.37
	15–18 years old	2.25	0.02 *	1.17–4.35
Gender	Male	1.45	0.05 *	1.00–2.18
Signs and symptoms	1–3 symptoms	3.06	<0.01 *	1.51–6.44
	≥4 symptoms	6.40	0.01 *	1.45–28.18
Fever and chills	Yes	0.37	0.01 *	0.18–0.77
Headache	Yes	0.50	0.04 *	0.26–0.95

* Statistically significant set at a *p*-value of 0.05

4. Discussion

This study examined mortality rates, survival probabilities, and risk factors among children in a South African province. Out of the 846 patient records reviewed and analyzed in the study, 111 patients died at a mortality rate of 12.82, which was high compared to other studies. However, it was similar to a study in India [27]. A cohort study conducted among hospitalized children aged 0–19 years reported a mortality of 17.5%, slightly higher than in our study [27]. However, in a retrospective study conducted in Iran, the mortality rate was 5.3% [28]. The difference in the mortality rate could be due to numerous factors, such as countries' public health systems (data management systems), access to healthcare systems, and preferred treatment methods.

4.1. Clinical Manifestations Observed in Patients Participating in the Study

In our study, the majority of participants reported the absence of any morbidities (n = 662; 75%) and exhibited a low mortality rate of 10.11 per 1000 individuals. This rate was comparatively lower than that of participants with one morbidity (13.27 per 1000) and those with more than two morbidities (35.97 per 1000 in days). These findings were previously highlighted in a systematic review and meta-analysis, indicating that children with morbidities are at a higher risk of experiencing severe COVID-19 compared to those without any morbidities [29]. Based on the available records, the following morbidities were identified: immunocompromised individuals (n = 38), cardiovascular conditions (n = 142), pulmonary disorders (n = 15), gastrointestinal conditions (n = 23), and diabetes mellitus (n = 99). Numerous scientists and researchers have indicated that children with diabetes, cardiovascular conditions, and lung-related ailments are at an elevated risk of mortality following COVID-19 infection [4,30–35]. Consistent with our study, individuals presenting these three conditions demonstrated increased mortality rates: diabetes was associated with a rate of 33.92 deaths per 1000 children-days, cardiovascular conditions with 21.58 per 1000 children-days, and lung-related conditions with 22.39 per 1000 children-days. Interestingly, individuals with compromised immune systems exhibited a lower mortality rate of 15.02 per 1000 children-days.

According to Kronbichler and colleagues, younger COVID-19 patients often exhibited asymptomatic cases, a phenomenon that may be attributed to their more robust immune systems, which could result from their active lifestyles and the presence of few or no morbidities [36]. In this study, the majority of patients were asymptomatic (n = 434; 47%). However, those who reported experiencing fatigue and shortness of breath demonstrated significantly higher mortality rates of 38.65 and 28.43 per 1000 child-days, respectively.

Furthermore, a statistically significant difference was observed between the survival rates of patients who experienced fatigue and shortness of breath and those who did not.

4.2. Risk Factors Influencing Time to Death Among Study Participants

In this study, the survival analysis indicated that children with one or more morbidities, specifically cardiovascular disease and diabetes, exhibited prolonged survival times, as illustrated in Figure 1. The presence of one or more morbidities adversely affected survival outcomes in the context of COVID-19, as the COVID-19 virus placed additional strain (worsened or triggered other body systems that were frailer) on specific bodily systems and processes, necessitating specialized care that may have been limited due to resource shortages.

Children aged 5 to 9 years (aHR: 2.09; 95% confidence interval [CI]: 1.01–4.31), those aged 10 to 14 years (aHR: 2.24; 95% CI: 1.15–4.37), and adolescents aged 15 to 18 years (aHR: 2.25; 95% CI: 1.17–4.35) were found to be at a twofold increased risk of mortality due to COVID-19 in this study. These findings are similar to studies elsewhere that found that older children were at a higher risk of severe COVID-19 complications, including death [4,37,38]. A number of factors could have contributed to this finding, such as socioeconomic factors, morbidities and viral variants. Male children were at a higher risk of succumbing to COVID-19 in the study. This finding is in line with previous studies [4,39–41]. Similarly to this study in the US, a national retrospective cohort study among children younger than 19 years found that male gender was a risk factor for COVID-19 severity [39]. Lastly, clinical manifestations related to COVID-19 have contributed to the severity of the disease in some patients [42]. A multi-national meta-analysis highlighted the role of more symptoms in the severity of COVID-19 among children [43]. In this study, the presence of one to three symptoms ($p < 0.01$) and the manifestation of four or more symptoms ($p = 0.01$) were identified as significant risk factors for the severity of COVID-19 within the study population. Notably, individuals exhibiting four or more symptoms were found to be at a sixfold increased risk compared to those presenting with one to three symptoms, which corresponds to a threefold higher risk. These findings are pivotal for the management of COVID-19 and may inform strategies for addressing future outbreaks and pandemics, particularly among pediatric populations.

Fever, chills, and headaches are prevalent symptoms of COVID-19 in pediatric populations [44–47]. This study found that children who experience either fever and chills or headache are at a lower risk of severe COVID-19 outcomes, including mortality. The presence of headache as a symptom of COVID-19 has been reported to be associated with a lower risk of severe effects, and the majority of patients are managed as outpatients [48].

4.3. Study Strengths and Limitations

This study had several strengths. The data were sourced from a provincial database used for official reporting to the National Department of Health during the COVID-19 pandemic. This dataset facilitated the analysis of morbidities, such as cardiovascular issues and diabetes, in children from low- and middle-income countries. Additionally, access to discharge or death dates allowed us to conduct a survival analysis.

However, this study also had limitations. The secondary data were not originally collected for research purposes, which meant that some potentially valuable information was missing that could have enhanced the understanding of the COVID-19 phenomenon in a predominantly rural province. Specifically, data on the reasons for hospitalization, socioeconomic status, patient vaccine status, and types of diabetes were not available. Furthermore, since the study was conducted in a single province, the results may not be generalizable due to varying socioeconomic conditions in different provinces.

5. Conclusions

This study found that age and having morbidities, especially cardiovascular disease and diabetes, influenced survival time for children with COVID-19. Furthermore, male gender, morbidities (two or more), diabetes (as a morbidity) and symptoms (one or more) were risk factors for COVID-19. These findings can be used to inform public healthcare providers for disease management and planning and resource management for similar outbreaks and pandemics, especially in areas with limited resources. Additionally, more research should evaluate other risk factors (such as socioeconomic and environmental factors) and strategies to mitigate the risk factors that influence the severity of COVID-19 in children.

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Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki and approved by the Faculty of Health Sciences, Research Ethics Committee of the University of Johannesburg (REC 347-2020 and 20 September 2022).

Informed Consent Statement: Patient consent was waived due to the study using secondary data.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to patient safety and the Protection of Personal Information Act, 2013 (POPI Act, 2013).

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Appendix A

Table A1. Bivariate Cox regression analysis of death risk factors among COVID-19 patients in the study.

Factors		Crude HR	*p*-Value	95% Confidence Interval
Age	5–9 years old	2.63	0.01 *	1.30–5.32
	10–14 years old	2.94	<0.01 *	1.56–5.56
	15–18 years old	2.79	<0.01 *	1.49–5.25
Gender	Male	2.32	0.02 *	1.00–2.11
Number of morbidities	One morbidity	1.40	0.08	0.95–2.34
	≥2 morbidities	3.42	<0.01 *	2.13–5.50
Number of signs and symptoms	1–3 Symptoms	2.71	<0.01 *	1.77–4.16
	≥4 Symptoms	2.68	0.01	1.27–5.66
Immune-compromised	Yes	1.00	0.99	0.41–2.44
Cardiovascular conditions	Yes	2.13	<0.00 *	1.42–3.20

Table A1. *Cont.*

Factors		Crude HR	*p*-Value	95% Confidence Interval
Lung-related condition	Yes	2.01	0.17	0.47–5.47
Diabetes	Yes	3.30	<0.00 *	2.10–4.86
Gastrointestinal condition	Yes	0.87	0.81	0.28–2.74
Fever and chills	Yes	0.71	0.31	0.37–1.36
Headache	Yes	0.93	0.80	0.54–1.61
Runny nose and congestion	Yes	1.26	0.48	0.66–2.42
Cough	Yes	1.44	0.06	0.98–2.10
New/loss of taste and smell	Yes	0.95	0.89	0.44–2.04
Muscular pain	Yes	1.15	0.67	0.60–2.21
Nausea/vomiting	Yes	1.00	1.00	0.25–4.04
Fatigue	Yes	2.84	<0.00 *	1.71–4.71
Short of breath	Yes	3.10	<0.00 *	2.10–4.56
Sore throat	Yes	1.30	0.43	0.68–2.50

* Statistically significant set at a *p*-value of 0.05.

Table A2. Final model multivariate Cox regression analysis for non-significant death risk factors among COVID-19 patients in the study.

Factors		Crude HR	*p*-Value	95% Confidence Interval
Morbidities	Yes	1.72	0.11	0.88–3.36
Morbidities	1 morbidity ≥2 morbidities	0.53 0.71	0.23 0.72	0.19–1.48 0.10–4.79
Immune-compromised	Yes	0.89	0.86	0.25–3.13
Cardiovascular conditions	Yes	1.08	0.87	0.40–2.91
Lung-related condition	Yes	1.37	0.60	0.43–4.42
Diabetes	Yes	1.83	0.24	0.66–5.07
Gastrointestinal condition	Yes	0.64	0.52	0.16–2.55
Fever and chills	Yes	0.37	0.01 *	0.18–0.77
Headache	Yes	0.50	0.04 *	0.26–0.95
Runny nose and congestion	Yes	1.28	0.52	0.61–2.69

Table A2. *Cont.*

Factors		Crude HR	*p*-Value	95% Confidence Interval
Cough	Yes	0.66	0.08	0.41–1.06
New/loss of taste and smell	Yes	0.70	0.43	0.29–1.69
Muscular pain	Yes	0.75	0.45	0.36–1.57
Nausea/vomiting	Yes	0.90	0.89	0.21–3.87
Fatigue	Yes	1.43	0.24	0.79–2.60
Short of breath	Yes	1.55	0.11	0.91–2.65
Sore throat	Yes	0.90	0.80	0.42–1.95

* Statistically significant set at a *p*-value of 0.05.

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