GIS-based accessibility analysis:
An approach to determine public primary health care demand in South Africa

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‘One of the main problems with health care is not simply that it lacks quality and comprehensiveness but also that, because of maldistribution of facilities and their resources, it is often not easily accessible to those in need’ WHO (1993)
Outline

• Concerns in health provision in developing countries
• Addressing provision through Service Access Planning
• GIS-Based accessibility analysis model as an option
• Key challenges to application
• Application
• Preliminary results
• Concluding remarks
Planning for health care

- Provision of adequate basic health care is becoming more difficult:
  - Rapid growth of settlements and population
  - Urbanization of poverty
  - Slow economic growth

**CHALLENGE**: achieve maximum health benefits to the greatest number of people through efficient use of resources

- Health care planning requires a range of tools to evaluate service delivery system
- GIS-based accessibility tools can be usefully applied in support of some aspects of performance assessment
- Overall level of accessibility and availability can be assessed to assess performance
Objective 1: Improvement of service accessibility and availability from the perspective of existing and potential customers

Objective 2: Attraction of the threshold volume of customers that is needed to cover the overheads and make the service viable

Approach

- Process:
  - Analyse existing service accessibility and availability
  - Explore & adjust facility locations & sizes in relation to:
    - spatial distribution of demand
    - threshold targets
    - other facilities / clusters / nodes

WHO gets WHAT, WHERE and HOW?
What is accessibility analysis?

• Models the accessibility and availability of facilities, evaluating the spatial relationship between demand and supply for services

• It’s based on assumption of rational choice to use the closest facility

• At a strategic level analysis which takes the entire city / sub-region into consideration it shows whether provision is
  – sufficient and
  – equitably available
How does it work: inputs

- Population
- Road network
- Facilities
How does it work: process & outputs
Contribution of accessibility analysis to planning

- Accessibility modelling - improved means of measuring facility access and of identifying poorly served areas and backlogs (spatially)
- Inform long term plans
- Measure progress w.r.t. service delivery of services
- Assist in setting service standards and benchmarks
Key challenges to application

- GIS is proving to be a useful tool for service access planning,

  **BUT**

  - Based on untested assumptions in measurement
  - Lack of data inputs in many developing countries
  - This raises the question in how far contemporary GIS accessibility analysis is applicable in South African health planning practice of today

- **Two main challenges:**
  
  (a) What method is the best in determining demand in the absence of accurate databases indicating public versus private health care usage?
  
  (b) How accurate is a rational choice based model regarding people’s actual decisions?
Application in an urban context
Methodology: Analysis steps

1. Data preparation
2. Demand scenarios
3. Model catchments
4. Correlation analysis
5. Map actual catchments
Methodology: Datasets / preparation (1)

Analysis units
- Tessellation
  - Hexagons

Demand
- Dasymetric mapping
  - 2011 population

Facilities
- Capacity allocation
  - Community health centres
  - Clinics

Road network
- OD matrix
  - Connected travel network

Other datasets
- 5 km travel standard
- Headcounts
- TB patient register
Analysis units

- Tessellate study area into a detailed grid
- Consisting of hexagonal polygons of 20 ha each
  - Outputs produced at a detailed level
  - Hexagons nest
  - Better distance measure
Methodology: Data sets / preparation (3)

Demand

- 2011 StatsSA Census population data
- Data extraction
  - Age breakdown (>5 years and <5 years)
  - Five income segments (StatsSA)
- Disaggregate demand to analysis units using dasymetric mapping
Facilities

- 116 public primary health care facilities
- First point of contact
- Facility selection:
  - administered by the public sector,
  - fixed geographical location, and
  - accessible attribute data
- Total facility capacity = can accommodate **64 311 030** visits per annum

**CAPACITY ALLOCATION FORMULA**

\[
\frac{pw}{d} = n \quad (1)
\]

and

\[
n \times s \times ps \times d = \text{capacity} \quad (2)
\]

where,

- \(pw\) = professional nurse working days
- \(n\) = number of nurses at a facility per shift
- \(s\) = hours of operation of a facility
- \(ps\) = number of patients a nurse can attend to in one shift
- \(d\) = number of days per annum that the facility operates
Methodology: Data sets / preparation (5)

Road network

• Complete road and street network
• Create an origin-destination (OD) table based on the network
### Distance parameter
- National standard
- 5 km travel distance

### Headcounts
- 2011 PHC actual visits
- Total for entire city: 7,684,912

### TB patient register
- TB records with:
  - residential address
  - Actual facility visited
What method is the best in determining demand in the absence of accurate databases indicating public versus private health care usage?
The StatsSA general household survey data on the percentage of medically insured and uninsured population is used to proportionally allocate uninsured population per ward as the demand for this scenario.

Using the income classes, all persons in the low income group and 50% of persons in the middle income group are allocated to each ward as the demand for this scenario.

Using the income classes, persons from the highest income category are first assigned the status of “insured”, and then people from the next highest income category and so on until the total insured population has been assigned. Once the total number of insured population is reached, the remainder of the population is assigned the status as uninsured and therefore demand for this scenario.
Results: Modelled catchments
Results: Modelled catchments

- 77,831 allocated demand
- 70,792 allocated demand
- 36,135 allocated demand
- 23,473 allocated demand
Results: Modelled catchments
Results: Modelled catchments

Legend
- Regions
- Health facility
  - Clinic
  - CHC
- Road network
  - Main Roads

Date: 29 July 2013

Scenario 1
Demand: 6,711,292

Scenario 3
Demand: 7,120,648
Results: Preliminary findings

- Three demand scenarios analysed:
  - No significant difference in spatial extent of catchment areas of facilities
  - Significant demand increase per scenario: scenario 1 < scenario 2 < scenario 3
  - The total modelled demand in scenario 3 strongly correlated with the total number of PHC visits (headcounts) recorded in the city: moderate positive correlation of 0.35
How accurate is a rational choice based model regarding people’s actual decisions?

Comparing modelled demand to revealed demand
- using TB patient data as a proxy
Results: Revealed demand (using TB patient data as a proxy)

• 1% residing outside the city boundary
• 44% not residing in catchment areas of the facility they visited
• Significant flows in the direction of Johannesburg CBD
Concluding remarks

- Establishing the demand profile for public health facilities is crucial:
  - Population growth and migration trends
  - Continued change in demand

- Implications for this project:
  - Results emanating from the TB register suggest another round of analysis
  - The modelled demand catchments need to be compared to the catchments based on the actual visits to establish weighted zones / areas of influence, and
  - Develop or calculate the probability variance of rational choice vs. actual choice based on a distance measure to further enhance the model’s capabilities

- Steps to improved demand estimate for future health planning projects:
  - Improved algorithm to estimate demand
  - Availability of spatially linked population employment data
  - Detailed patient registers
Thank you

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