USING GIS FOR EVALUATING ACCESSIBILITY TO HEALTH CARE CENTERS IN JEDDAH CITY

Abdulkader A Murad, PhD.
Department of Urban and Regional Planning,
Faculty of Environmental Design,
King Abdulaziz University,
Jeddah, Saudi Arabia.
E-mail: gis_planning@yahoo.com
1- Introduction
2- Background
3- Methods
4- Results & Discussion
5- Conclusion
INTRODUCTION

The purpose of this paper is to discuss a GIS application created for defining spatial accessibility to health centers at Jeddah city, Saudi Arabia.

This application produces three accessibility models:

1- Distance to the nearest health center,
2- health center-to-population ratio, and
3- A combined health care accessibility indicator based on spatial interaction technique.
Each one of these models aggregates the city into accessibility zones. The resulted zones can be used by health planners in deciding whither current health facilities covering all city parts or not.

Several ArcGIS software functions and modules are used in this application. These include Spatial Analyst module and Network Analyst module.
LOCATION OF JEDDAH, SAUDI ARABIA
LOCATION OF JEDDAH, SAUDI ARABIA
LOCATION OF JEDDAH, SAUDI ARABIA
GIS has been widely used in health care planning due to the following 4 factors:

1- The increasing availability of geo-coded health data that lead to having health information systems.
2- The availability of digital geographic data at micro and/or micro scale that has several GIS coverage with enormous attribute data such as land use, ownership, etc.
3- GIS software such as ArcGIS produced by ESRI become inexpensive and easier to use and runs on a wider range of platforms, and

4- The availability of spatial analysis tools, as separate software modules or embedded is GIS.
1- **Geo-coding**

This function is used by several applications to create points on a map from a table of addresses.
2- Overlay Analysis

The concept of overlay analysis is one of the major GIS procedures that are used by several studies. It manipulates spatial data organized in different layers to create combined spatial features.

Union, Interact and Identity are the major polygon overlay functions.
GIS TOOLS FOR HEALTH CARE PLANNING

- 3- Network Analysis
  - This type of analysis can be used to find the shortest routes or to find the service area of any facilities.
  - It uses network data model to produces the analysis outputs.
The potential applications of GIS in health studies are:

- 1: disease mapping and geographical correlation studies,
- 2: patterns of health service use and access,
- 3: environmental hazards and disease clusters, and
- 4: modeling health impacts of environmental hazards
BACKGROUND

- 5: The surveillance and monitoring of vector borne disease,
- 6: Water borne diseases,
- 7: Environmental health,
- 8: Modeling exposure to electromagnetic fields,
- 9: Quantifying lead hazards in a neighborhood,
- 10: Predicting child pedestrian injuries, and
- 11: The analysis of disease policy and planning.
GIS could also be used for
1: exposure assessment, 
2: identification of study populations, 
3: disease mapping, and 
4: public health surveillance.
Severe Trauma Injuries, 2001–2006
by Provincial Health Service Delivery Area
and Census Subdivision Geography Type

Source: BC Trauma Registry; BC Vital Statistics
Risk analysis using the Rapid Inquiry Facility RIF
Cumulative HIV/AIDS rates, Alabama Counties.

Source: Alabama Department of Public Health
Distribution of residence of inpatients. (A) All inpatients (n = 8,177) admitted to Niigata University Hospital during the period from April 2003 to March 2005 were geocoded to a GIS map of Niigata Prefecture. (B) All inpatients under 15 years of age (n = 1,323) were also plotted on a map.
Referral to aftercare. (A) Kernel density plot of patients who were referred to the Outpatient Department of Niigata University Hospital. (B) Kernel density plot of patients who were referred to outpatient departments of other hospitals. Dots represent the locations of hospitals with paediatricians.
Maps of health statistics can be invaluable in understanding local patterns of disease and their geographical associations. They have the advantages of conveying instant visual information accessible to non-experts as well as public health professionals though their interpretation.
All of the above applications indicate that GIS has very useful tools and functions for any health care study.
The data base of this application covers:

Location of health centers at Jeddah city which is created as a point feature and all attribute data about health centers are saved at the attribute table of this file.
The second main GIS data feature is the line feature which has one dimensional shape that represent geographical features too narrow to depict as area.

GIS software store lines as a series of ordered x,y coordinates with relevant attributes. For the presented application, road network of Jeddah city is represented as line feature with attributes about length and type of each road at this city.
Spatial distribution of health services

There are 39 health centers distributed at Jeddah city.

- The location of health centres in Jeddah city were plotted on GIS as point features map and classified based on their supply or service.
- There were 11 types of health services supply for each centre: 1 - physicians (general practitioners, GPs), 2 - family physicians, 3 - dentists, 4 - nurses, 5 - midwives, 6 - pharmacists (pharmacologists), 7 - laboratory technicians, 8 - x-ray technicians, 9 - administrators, 10 - servants, and 11 - others.
Spatial distribution of health services

- The next 2 figures show a classification model for a health centre based on the number of physicians.
- and demonstrate health centres based on the number of dentists.
CLASSIFICATION OF HEALTH CENTERS BASED ON NUMBER OF PHYSICIANS
CLASSIFICATION OF HEALTH CENTERS BASED ON NUMBER OF DENTISTS
Each health centre has different amount of physicians or dentists.

Alsafa Centre and Gulail Centre engage more physicians than Alsharafia Centre and Althayuar Centre.

In Alazizia Centre there are two dentists while in Alselamainah Centre and Almarwah Centre there are no dentists at all.

One reason for this difference is related to the size of existing demand.
GIS was applied to classify more types of supply known as multiple data classification, the so-called multiple queries by using logical operations that deal directly with the database and allow the user to identify and select features by a special set of criteria with more than one parameter.
One could find out health centres with many physicians but without any dentists or with less servants.

The features were identified and selected from the database and highlighted on the map according to a combination of several conditions.

These features can be saved in a new coverage for further analysis.
The presented paper has detected which centres are owned by the health authority and engage more than 3 physicians.

Several health centres in Jeddah city are located on rented buildings and engage numerous physicians. e.g. Ghulail and Aljameaa centres are in the southern area while Alzahraa and Alsalamah centres are in the northern area.
RENTED HEALTH CENTERS WITH MORE THAN 3 PHYSICIANS
Several health centres such as Alrabwa, Alzahra and Alnaeem providing large and various types of health services to the public by family physicians and dentists.

Alsafa and Alsohaifa centres, however, do not engage dentists and family physicians at all.

The local health authority can therefore use this technique to find quick and clear answers about any issues related to quality and quantity of health services delivered at Jeddah city.
HEALTH CENTERS WITH FAMILY DOCTORS AND DENTISTS
The presented application has selected distance to provider method and produces accessibility indicators to health centers in Jeddah city.

One way of defining accessibility to health centers is by knowing how far patients live from their nearest centers.
In order to define the level of accessibility to health centers, GIS proximity analysis was used and the output of this model classifies the city into different zones based on the distance between clinic location and city districts.

Based on this output, several parts of the city are located at areas with more than 2 KM accessibility zone. These areas are mainly situated north and east of the city with some to the west.
HEALTH CENTER-TO-POPULATION RATIO

- One way of defining accessibility to health center is by identifying the provider-to-population ratios.
- These measures are useful for gross comparisons of supply between geopolitical units or service areas, and are used by policy analyst to set minimal standard of local supply, and to identify under served areas.
ArcGIS spatial analyst is used by the present study to create a GIS model that defines the provider-to-population ratio for health centers in Jeddah city. In order to build and produce this model the following process were covered:

First: Provider density is created for each health center. This output is drives based on the density function of ArcGIS software. This function calculates doctor’s density on every health center based on the available supply.
Second: Population density is built for Jeddah city using the same GIS function (density). This model is produced based on GIS coverage that shows districts centers.
Third: The provider density (in physician per square km units) is divided by the population density layer cells (in person per square km units). This step is achieved using ArcGIS model builder and based on the arithmetic overlay function.
PHYSICIAN-TO-POPULATION RATIOS AT JEDDAH CITY

<table>
<thead>
<tr>
<th>Physicians-to-population ratios</th>
<th>Health centers</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 0.08</td>
<td></td>
</tr>
<tr>
<td>0.09 - 0.15</td>
<td></td>
</tr>
<tr>
<td>0.15 - 0.25</td>
<td></td>
</tr>
<tr>
<td>0.25 - 0.39</td>
<td></td>
</tr>
<tr>
<td>0.39 - 2.06</td>
<td></td>
</tr>
</tbody>
</table>

Road1

10000 0 10000 20000 Meters
Gravity model in general and spatial interaction in particular can be used to provide the most valid measures of spatial accessibility. These models combined indicator of distance and availability of health supply using the following formula:
\[ P_{ij} = A_i \times R_i \times D_j \times f(C_{ij}) \]

Where \( P_{ij} \) = flow of patients from residential area \( i \) to health center \( j \),
\( R_i \) = patient demand in area \( i \),
\( D_j \) = number of physicians at health center \( j \),
\( C_{ij} \) = is a measure of the cost of travel or distance between \( i \) and \( j \), and
\( A_i \) = is a balancing factor.
In order to map out the results of this model, two health centers are selected which are North Obhur and South Iskan centers. Both results show the decreasing zones of interaction for the selected centers due to distance decay and proximity to competitors.
PREDICTED DEMAND FLOWS TO NORTH OBHUR HEALTH CENTER

- North obhur center
- Road
- Spatial interaction
  - 0 - 8.581
  - 8.581 - 38.011
  - 38.011 - 99.676
  - 99.676 - 224.687
  - 224.687 - 1920.29
PREDICTED DEMAND FLOWS TO SOUTH ISKAN HEALTH CENTER

5000 0 5000 Meters

Spatial interaction
0 - 137.831
137.831 - 785.557
785.557 - 2748.68
2748.68 - 7282.88
7282.88 - 16198.6

Road
South iskan center
Spatial interaction
0 - 137.831
137.831 - 785.557
785.557 - 2748.68
2748.68 - 7282.88
7282.88 - 16198.6
The present study have used several GIS function and models for the purpose of defining spatial accessibility to health centers in Jeddah city. Different data sets were collected and captured at ArcGIS software. The created database is used to build three spatial accessibility models. Health planners at Jeddah city can use these models to evaluate the current status of health centers location. One of the main results founded from the created accessibility models is that there is a need to increase the current supply of health centers at Jeddah city. This increase if implemented, a better health care service will surely be achieved at Jeddah city.
THANK YOU