GIS APPLICATIONS IN PUBLIC HEALTH MANAGEMENT

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Public health is the "the science and art of preventing disease, prolonging life and promoting health through organized efforts and informed choices of society, organizations, public and private, communities and individuals.

Of late, GIS playing an important role in public health and health services planning.
Definition of public health is used in different ways by different groups. In general, public health differs from individual health. Public health is

❖ focused on the health of populations rather than on individuals

❖ focused more on prevention than on treatment,

❖ Operates mainly by government rather than private.
During the Middle Ages a number of attempts in public health were made:

❖ to cope with the unsanitary conditions of the cities and, by means of quarantine,
❖ to limit the spread of disease;
❖ establishment of hospitals and
❖ provision of medical care and social assistance.

1802 caricature of Edward Jenner vaccinating patients.
Public health nursing made available through child welfare services in U.S. since 1930s
The concept that location can influence health is a very old one in medicine. As far back as the time of Hippocrates (c. 3rd century BC), physicians observed that certain diseases tend to occur in some places and not others.
• Understanding the relationship between location and health can greatly assist us in understanding, controlling and preventing disease, and in better healthcare planning, with more efficient and effective resource utilisation. This should ultimately lead to better healthcare outcomes and improved health for everyone.
First disease map was created by German physician Leonhard Ludwig Finke in 1792, which became an important tool for understanding:

i. incidence and spread of infectious diseases

ii. identifying associations between disease and spatially-distributed environmental conditions.
By using a map to examine the geographical (spatial) locations of cholera cases in relation to other features on the map (water pumps and cemetery of plague victims), Snow was actually performing what is now known as spatial analysis.

< Dr John Snow (1813-1858), a legendary figure in the history of public health, epidemiology and anesthesiology
Based on this information, study the local council deactivated the pump that was the source of cholera.
This map is a digital recreation of Dr Snow’s hand-drawn map. The 1854 cholera deaths are displayed as small black circles. The grey polygon represents the former burial plot of plague victims.

The Broad Street pump (shown in the centre of the map) proved to be the source of contaminated water, just as Snow had hypothesised.
These early mapping techniques proved extremely useful for generating geospatial maps which correlated with the incidence and spread of diseases.

The main obstacles for early physicians/medical geographers was limited technology and acquisition of data.

Maps had to be drawn by hand, making them difficult to reproduce, and since physicians were the ones with medical data, it was they, not geographers, who first mapped disease patterns.
Rapid advancements in computer technology during the latter half of the 20th Century brought about an enormous transformation in medical sciences.

By the late 1960s, several computer-mapping programs began to revolutionize the discipline, catalyzing the development of modern automated mapping procedures, which allowed for information to be more readily and efficiently updated.

Maps could now be generated much faster and with greater precision than before, and disease diffusion could be more easily be mapped and analyzed.

One of the first notable medical GIS software is referred to as the Geographic Analysis Machine (GAM), developed in 1987 by Openshaw and his colleagues and used to analyze locations of clusters of Leukemia in 1983.
Emergency Services
Service delivery
Disease & risk factor mapping
Time trends
Environmental health
Natural Disasters
Education & Research
Medical Care
Modelling
Real time users

Voice Recognition

“Want ambulance

Hospital

Service provider

Map Database

Nearest location

Location Service

GPS

Tracking route

Other Network Services
For Decision making - require information like

Where ...? Incident exact location, Critical Infrastructure

Where is ...? Nearest Hospital, Fire Station ...

Where do I ...? Safety storage siting ...

What are ...? Sensitive & Vulnerable Areas...

What if...? Facility provided...

Which ...? Optimum Route ...

How many...? People are affected by floods ...

How does...? Sustainable development ...

What has changed ...? Deforestation, Disasters, ...

g eography matters...

to all of us
Network analysis in GIS enables to analyze efficiency of infrastructure such as

- emergency response systems,
- road network and transport routes
- radio communications,
- cell towers, etc
Accessibility

The degree of accessibility of health care institutions is one of the most significant indicators for measuring the efficiency of a health care system.

Accessibility is an indicator that reflects the number of health care institutions, their geographical distribution and the impact of different types of barriers (economic, social, cultural, etc.).

Analysts have been mainly concerned with geographical accessibility. Over the last twenty years, GIS has provided valuable tools for the measurement of geographical accessibility.
The access of public to health care institution could be seriously restricted by distance and quality and quantity of the road network.

Longer distances may affect especially the access of elderly and of physically-impaired people to health care.

In general, longer the distance to health care facilities higher the risk of fatalities.

GIS plays vital role providing better emergency facility and optimal route and demarcate the service area for accessibility of emergency services in a short time span through network analysis.
- Location Analysis: location and access to different health facilities can be displayed with zoom in feature to specify location.
GIS IN HEALTH MANAGEMENT

Accessibility to OPD (Out Patient Department)
People accessing the health facility

3.14 Sq Km
Approx Population ~12,500
The analyses rest upon the spatial relationship between the centers of settlement and health care institutions. Proximity plays a vital role in emergency situations. The patients should be rushed to hospital as soon as possible and in cases that require immediate intervention. This map shows the 1 km buffer zones for hospitals.
“shortest distance” analysis.

Global Positioning System, combined with real-time GIS provides efficient routing of Ambulance trips by finding shortest and quickest routes and avoiding routes with traffic congestion. This can reduce the response time in emergency situations and help saving more lives.
Closest facility:

- Closest facility solver
  - Find the routes from an incident to all facilities that can be reached within 15 minutes of driving.
With the use of remote sensing & GIS technology we can calculate accurate distance & time from incident to facility. Here calculate distance (meter) & time (minute) from incident (Bus Stop) to facility (Hospital).
Planning for future health services

Health services planning and GIS are two interconnected concepts that require spatial data. The location of health care institutions, distribution and characteristics of patients are primary spatial data that should be considered during the planning of local health care services.

Spatial querying tools and related GIS capabilities such “buffer” and “overlay” make GIS a very efficient tool in querying the accessibility of health care institutions both for today and in the future.
Rural Health Service – planning for a PHC

Taluka Savantvadi

Infrastructure
- Primary Health Centre (PHC)
- Medical Shops
- Govt. Offices
Rural Health Service

Taluka Savantvadi

Villages Benefited
Medical facility reaching
8 KM radius
Rural Health Service

Taluka Savantvadi

NEED of Primary Health Centre

Area without any PHC
GIS in Epidemiology

- Epidemiology is the study of the distribution and determinants of disease in populations, to seek the causes of both health and disease.

- Epidemiologist—a medical detective who links observed problems with potential causes, to arrive at a diagnosis and design and implement a mitigating response.
Overlay and relative weightage methods in Spatial analysis and modelling of GIS enables to

- identify risk areas of the disease
Spatial Modelling of Malaria Risk zones

David Chikodzi
Journal of Geosciences and Geomatics
Eight risk factors were used in the model build up.

Each risk factor was first spatially classified in a geographic information system (GIS) according to how it promotes malaria incidence.

The factors were then weighted using a pair wise comparison matrix which is part of analytical hierarchy process (AHP).

The final malaria prediction model was then prepared by combining all risk factors and their derived weights through the index overlay model in a GIS.
Once all the spatial data are available in the computer in a geo-referenced format (i.e. referenced to earth coordinate system using the properties of map projection and geodetic datum), any two or more spatial datasets when displayed on the computer screen using a GIS software will sit one over the other if those datasets belong to the same area (i.e. having the same latitude and longitude extents); Understandably, it is possible with GIS to assemble several individual spatial data on any theme or themes into a single mosaic to obtain a larger regional, national or global view.
The environmental layers are overlaid (intersected) with malarial incident cases and malaria risk areas were derived.

Malaria Risk map of Masvingo province
Variations in the risk levels of (a) Pf malaria, and (b) Pv malaria in Visakhapatnam district.
GIS application in Environment Vs disease
Visakhapatnam District

52.5% 47.5%
They clear the forest cover and destroy it by setting fire, the land is used for cultivation of annual crops like millets and maize. It was common practice that once the land loses its fertility after extracting crops for few years, they move to another area and start clearing new forest areas. Hence this practice is known as **shift cultivation**.
Under this pattern of agriculture, the forest vegetation have been completely destroyed and denuded. The soils got impoverished mainly due to soil erosion. Thereby most of the nutrients are removed by erosion.
Incidence of Goitre
About 90% of iodine intake of iodine is through food and drinking water.

The iodine content of the soil determines its supply to human beings.

Sea foods (fish and salt), cod liver oil are the best sources of iodine. It is available in small quantities in milk, meat, vegetables, and cereals.
Contributory factors for the incidence of goiter disease Visakhapatnam district

❖ Deforestation

❖ High relief

❖ High rainfall

❖ Away from the sea - Non availability of sea food

❖ Low iodine content in the ground water, milk and vegetables and other foods
Deforestation in Visakhapatnam District
Guinea worm infestation
In Ananatapur District
Guinea worm disease

Male and female *D. medinensis* worms. The female worm is the larger of the two. The ruler at the left is in Cms.
ANANTAPUR DISTRICT

Annual Rainfall distribution
Guinea worm prone zones of Ananatapur district
Distribution of Step wells, tanks and persons infested in Guinea worm prone zones in Anantapur district

<table>
<thead>
<tr>
<th>Name of the taluk</th>
<th>No. of step-wells</th>
<th>No. of tanks</th>
<th>No. of persons affected</th>
<th>No. of villages affected</th>
<th>Population at risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uravakonda</td>
<td>23</td>
<td>4</td>
<td>1,226</td>
<td>14</td>
<td>30,952</td>
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<tr>
<td>Gooty</td>
<td>7</td>
<td>12</td>
<td>98</td>
<td>10</td>
<td>28,915</td>
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<tr>
<td>Kanekal</td>
<td>5</td>
<td>3</td>
<td>17</td>
<td>10</td>
<td>35,510</td>
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<tr>
<td>Tadipatri</td>
<td>3</td>
<td>2</td>
<td>15</td>
<td>3</td>
<td>3,940</td>
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<tr>
<td>Kalyandurg</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>7,580</td>
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<tr>
<td>Rayadurg</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>4,100</td>
</tr>
<tr>
<td>Singanamala</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2,389</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>42</strong></td>
<td><strong>25</strong></td>
<td><strong>1,366</strong></td>
<td><strong>44</strong></td>
<td><strong>1,23,386</strong></td>
</tr>
</tbody>
</table>
Trends in Guinea worm incidence in Andhra Pradesh (1984 - 1992)


No. of cases: 0 to 1200

Legend: Guinea worm cases
Analysis of Filariasis Prone zones
FILARIASIS - DISEASE MANAGEMENT STRATEGIES
Land use/Land cover map of Vizianagaram town with particular reference to Water bodies (Extracted from SOI Toposheet at 1:50000 Scale, Surveyed during 1971-1972)
Potential Mosquito breeding ditch encircling Vizianagaram Fort

Fort Wall

MOA

T
Pedda cheruvu before 2003

170 acres-large manmade lake, ‘Pedda Cheruvu’.
Dr. Prakasam Tata, designed and installed a waste water treatment system to curb the mosquito menace to ‘Pedda Cheruvu’.
Filariasis incidence in Vizianagaram Town between 1997 - 2010
Chronic Kidney Disease with unknown Etiology (CKDu)
Chronic kidney diseases (CKDu) in Uddanam region
Location of Kaviti mandal in Srikakulam district of Andhra Pradesh
GENDER-WISE INCIDENCE OF CKDu in KAVITI MANDAL

Male: 422
Female: 17
Total: 59
AGE-WISE INCIDENCE OF CKDu in KAVITI MANDAL
Ground water sources and CKDu incidences in Kaviti Mandal
## Ground water properties in Kaviti Mandal

<table>
<thead>
<tr>
<th>Minerals/ Physical Properties</th>
<th>Quantity in Kaviti waters</th>
<th>Desirable recommended amounts by WHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>40 - 90 mg/lt</td>
<td>75 mg/lt</td>
</tr>
<tr>
<td>Chlorides</td>
<td>70 - 197 mg/lt</td>
<td>200 mg/lt</td>
</tr>
<tr>
<td>Magnesium</td>
<td>21 – 33 mg/lt</td>
<td>50 mg/lt</td>
</tr>
<tr>
<td>Iron</td>
<td>0.01 to 0.05 mg/lt</td>
<td>0.1/mg/lt</td>
</tr>
<tr>
<td>Fluorine</td>
<td>0.5 and 0.8/lt</td>
<td>0.6 mg/lt</td>
</tr>
<tr>
<td>TDS</td>
<td>185 to 287 mg/lt</td>
<td>500 mg/lt</td>
</tr>
<tr>
<td>PH</td>
<td>7.8 to 8.3 percent</td>
<td>6.5 to 8.5 %</td>
</tr>
<tr>
<td>Arsenic</td>
<td>Not analyzed</td>
<td>0.01 mg/lt</td>
</tr>
</tbody>
</table>
Land use / land cover

Spatial distribution of wells and tube wells Vs. CKDu incidences in Kaviti Mandal

Ground water sources
Identification of Filariasis Prone zones
GIS and Heat Wave analysis
Global Temperatures increased by 0.8°C during the last century of which 0.6°C was in the last three decades.
Temperature Anomaly (°C)
(Difference from 1980-2015 annual mean)

Record Years

1880
Andhra Pradesh
Map showing Temperature deviations from the normal between 22 May to 1 June 2015
Heat Index VS human mortality in Andhra Pradesh during 2015 Heat wave
Heat Wave prone zones in Andhra Pradesh - 2015
Date-wise human mortality in Andhra Pradesh during 2015 Heat wave

Total deaths 2677

District-wise human mortality
Limitations of GIS

• Communication Gaps between epidemiologists & spatial professionals
• Require uniform data standards
• Privacy issues and spatial aggregation
• Lack of policy for sharing intersectoral/interministrial data sharing
HEALTH CARE REFORM

GTS/RS

SAS, SPSS, S+,
Thank You