KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS

TERM PAPER OF

GIS AT PUBLIC HEALTH

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LIST OF FIGURES

ABSTRACT

GIS provides a great help in public health sector. It provides variety medical and online services for patients, management, and medical care staff. GIS brings in ease way of visualizing and analyzing epidemiological/disease and its corresponding data, trends, dependencies and inter-relationships. GIS can acquire, store, manage, and geographically integrate large amounts of information from different sources, programs and sectors. GIS establishes a unified platform for union of multi-disease surveillance/surveys activities. Health data management can be reached through standardized geo-referencing of epidemiological data structure. When basic structure is available, it becomes easy to establish a surveillance system for any other disease. Surrounding environment and existing health social infrastructures can be linked to public health resources, specific diseases and other health events to be represented in a rich informative map.

GIS can help in generating thematic maps ranged color maps or relative symbol maps to indicate the intensity of a disease. Because of ease of GIS representation, unlike tables and charts, maps developed using GIS can be extremely effective means of communicating messages clearly even to those who are not familiar with technology. The recent advancements in GIS technology in terms of web-based provide kind of dynamic maps on the Internet to assist patients in locating the most convenient health medical care services quickly and easily.

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CHAPTER ONE: INTRODUCTION

1.1 Background

General framework of geographic representation helps in rectifying most health and human service problems facing the world today. Knowing problems of medical epidemiology and access to healthcare requires comprehensive understanding of related associated geography. Thus, Geographic Information System (GIS) is often used to provide useful means of visualizing and analyzing epidemiological/diseases data, revealing trends, dependencies and interrelationships. GIS can acquire, store, manage, and geographically integrate large amounts of information from different sources, programs and sectors.

GIS establishes a unified platform for union of multi-disease surveillance/surveys activities. Health data management can be reached through standardized geo-referencing of epidemiological data structure. When basic structure is available, it becomes easy to establish a surveillance system for any other disease.

Surrounding environment and existing health social infrastructures can be linked to public health resources, specific diseases and other health events to be represented in a rich informative map. Such information when mapped together creates a powerful tool for the monitoring and management of epidemics. GIS helps generate thematic maps that depict the intensity of a disease or vector. It can create buffer zones around selected features and then combine this information with disease incidence data to determine how many cases fall within the buffer. It can also map the impact zone of vector breeding site, where control activity needs to be strengthened. GIS can identify catchment areas of health centers and also locate suitable sites for a new health facility. It can overlay different pieces of information and carry out specific calculations.

Interactive queries of information provided by GIS can be applied at a map, a table or a graph. GIS permits a dynamic link between databases and maps so that data updates are automatically reflected on the maps. Dynamic maps published on the Internet assist patients in locating the most convenient health services easily. GIS can process aerial/satellite images to allow information like temperature, soil types and land use to be easily integrated, and

spatial correlations between potential risk factors and the occurrence of diseases to be determined.

1.2 GIS Definition

The term "GIS" can refer to Geographic Information Systems or geographic information science. GIS is not just a map-making tool. GIS is way more than spatial representation. It provides the ability to analyze dynamically collected spatial data and represent them easily and clearly.

GIS can be defined as a computer-based system for integrating and analyzing geographic data (Cromely & McLafferty, 2002). GIS technologies and systems can show locations, quantities, densities, and proximities. It can reveal patterns and relationships. It can be used to create maps, models, and graphs.

Four functions distinguish GIS technology. First is the ability to store and compute or display spatial relationships between objects. Second is the ability to store many attributes of objects. Third is the ability to analyze spatial and attribute data in addition to simply managing and retrieving data. Fourth is the ability to integrate spatial data from many sources. Cromley and McLafferty (2002) further identify three broad categories of GIS functions: spatial database management; visualization and mapping; and spatial analysis.

1.3 Advantages of GIS in Health

GIS has several advantages over conventional methods used in health planning, management and research. GIS can be used to capture, store, handle and geographically integrate large amounts of information from different sources, programs and sectors including epidemiological surveillance, census, environment and others. Surveillance or researches of diseases requires continuous and systematic collection and analysis of data.

GIS can eliminate the duplication of effort involved in data collection and hence substantially reduce the cost involved. GIS serves as a common platform for the convergence of multi-disease surveillance activities. Each data record has to be geo-referenced to a desired level of accuracy. Standardized geo-referencing of epidemiological data facilitates structured approaches to data management (Brewer, 2002).

GIS can access additional information from several different sources and systems. Global positioning systems (GPS) for example can be used to obtain locations of point features on a map, such as wells or movable infected tanks on trucks precisely. GIS can process aerial or satellite imageries to allow information such as temperature, soil types and land use to be easily integrated and spatial correlations between potential risk factors and the occurrence of diseases to be determined (Brewer, 2002). Latest, accurate, low cost maps are essential for epidemiological surveillance (disease researches).

1.4 Incorporating Health Data at GIS

In health sector, GIS provides great tools for geographic and spatial analysis, and it allows you to visualize data that may have gone unnoticed in spreadsheets, charts, and other reports. Integrating database operations, such as query and statistical analysis with geographical and visualization, it will give ability to predict, plan, and recommend course of actions and strategies. GIS can and integrate different types of health data such as shown in Figure 1.

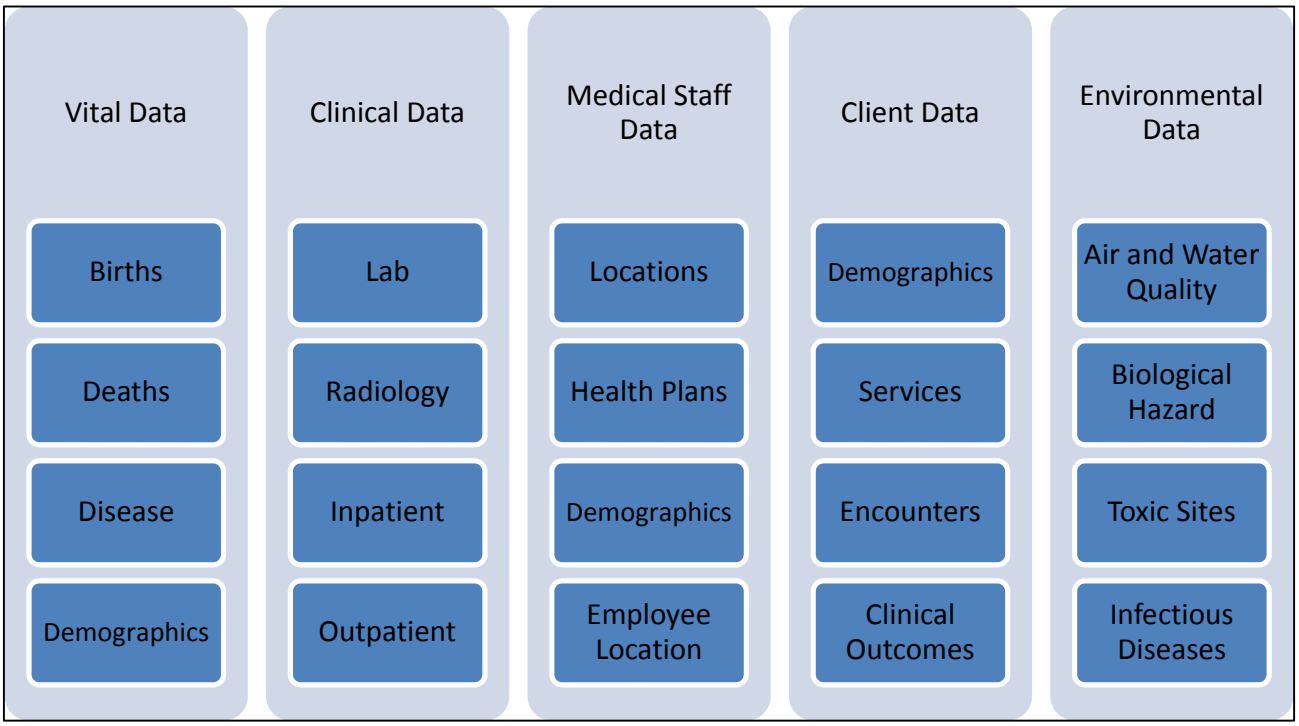
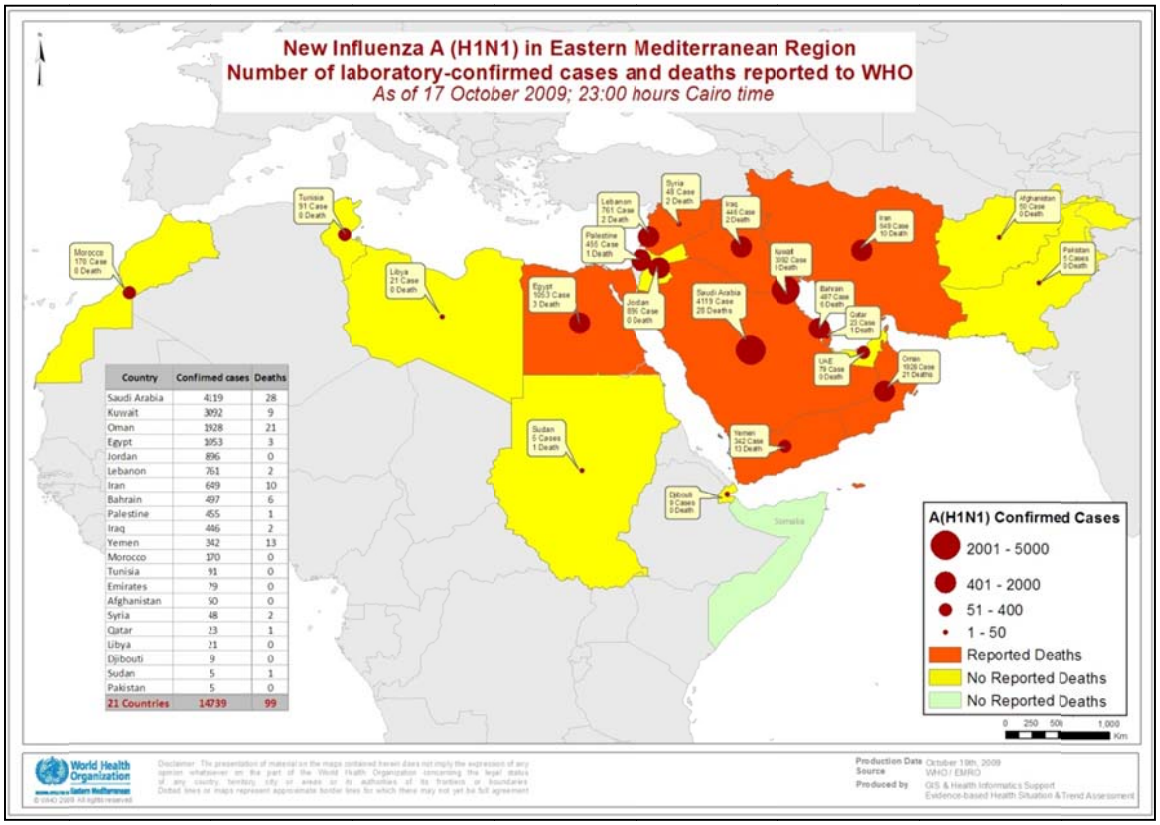


Figure 1: Different type of health organization data (Applications of GIS in Health Sciences)

CHAPTER TWO: GIS and Health

2.1 Public Health Mapping

One of the most well-known maps in the field of public health was John Snow's map of the Soho neighborhood of London, which showed a relationship between cases of cholera and water supplies and wells (Johnson, 2004). With revolutions of technologies and use of geographic information for public health practice, maps have long been a part of disease research and surveillance. Figure 2 shows an example of mapping H1N1 infections at Middle East countries.



Country	Confirmed cases	Deaths
Saudi Arabia	4119	28
Kuwait	3092	9
Oman	1928	21
Egypt	1053	3
Jordan	896	0
Lebanon	761	2
Iran	649	10
Bahrain	497	6
Palestine	455	1
Iraq	446	2
Yemen	342	13
Morocco	170	0
Tunisia	91	0
Emirates	79	0
Afghanistan	50	0
Syria	48	2
Qatar	13	1
Libya	21	0
Djibouti	9	0
Sudan	5	1
Pakistan	5	0
21 Countries	14739	99

Figure 2: H1N1 Confirmed Cases of Infection and Intensity at Middle East. (World Health Organization, 2009)

Track social/economic data using maps has a long history. In the late 19th and early 20th centuries, Charles Booth created poverty maps of London (Spielman & Thill, 2008). The United States has conducted a decennial survey since 1790; the survey has grown to include detailed information on income, transportation patterns, occupations, and other data, based on geographic locations. These types of data are becoming increasingly important in studies of the social determinants of health.

The use of maps for public health research expanded dramatically in the 20th century as technology advanced and it continues to boom in the 21st. Public health researchers and practitioners use GIS in a number of ways. Epidemiologists (Disease researchers) and environmental scientists use mapping technologies for tracking disease outbreaks and examining the relationship of health outcomes to toxic sites. Other public health uses of GIS include health policy, service areas, health surveillance, emergency readiness, needs assessments, and health impact assessments.

GIS can be used also by behavioral health researchers to establish correlations between environments and health outcomes. The significance of geospatial data is becoming clearer to formulate effects of social and physical environments on health.

For example Brower and Carroll (2007) used GIS mapping and 2003 crime data from the University of Wisconsin-Madison to address consequences of student drinking. They examined the time as well as location of crime reports and found that different categories of crime showed different temporal and spatial patterns. The results led directly to changes by city and university officials in addressing high-risk drinking.

Lyn Stoesen, 2008 stated another example that Owen et al. (2007) examined the physical attributes of residential neighborhoods, obtaining measures of connectedness and proximity using GIS databases, to examine walking behaviors. A "walk ability index" was created using street centerline data, land use, zoning data, shopping center location data, and survey data within a GIS application.

2.2 GIS and Visualization

Visualizing and presenting spatial information is provided by GIS at level of individual occurrence and conduct predictive modeling. GIS determines geographical distribution and variation of diseases, and their prevalence and incidence. For example, H1N1 confirmed cases of infection and intensity around world is shown in Figure 3.

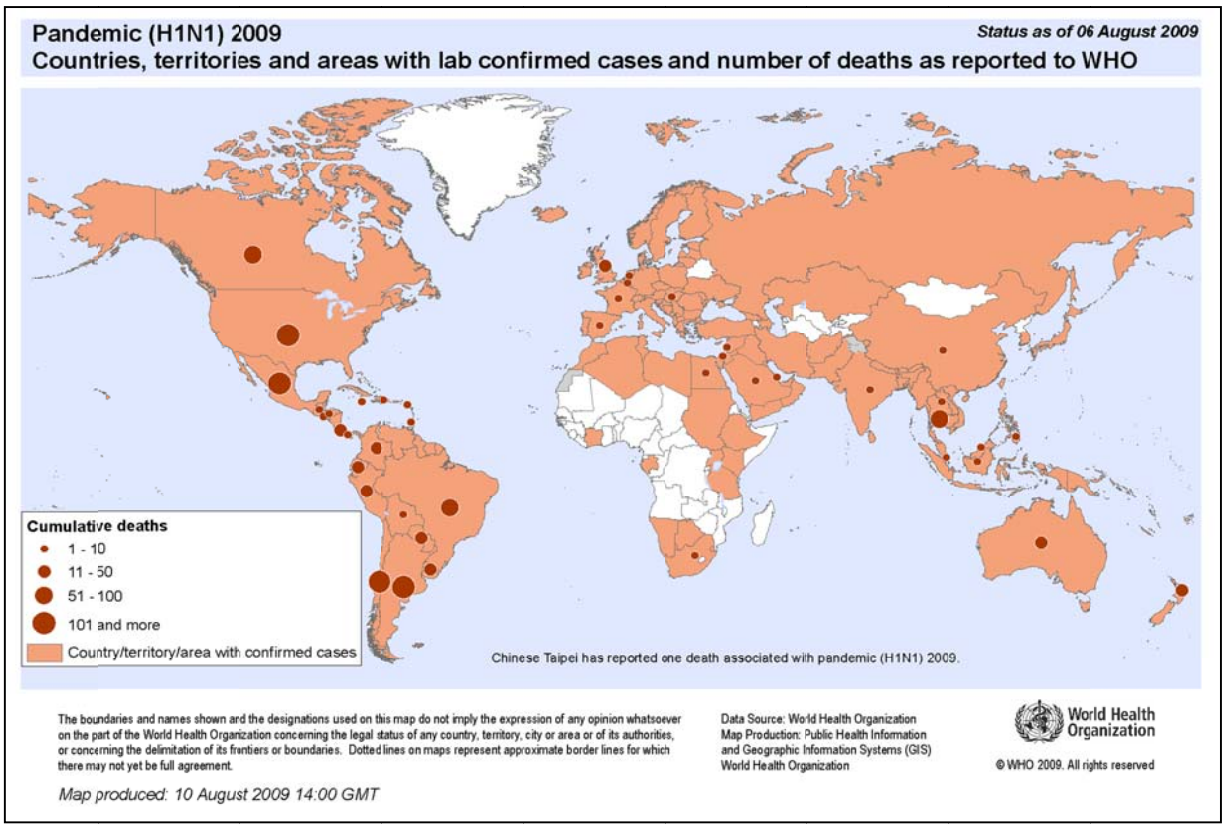


Figure 3: H1N1 Confirmed Cases of Infection and Intensity around World. (World Health Organization, 2009)

In addition, GIS can help in generating thematic maps ranged color maps or relative symbol maps to indicate the intensity of a disease. Because of ease of GIS representation, unlike tables and charts, maps developed using GIS can be extremely effective means of communicating messages clearly even to those who are not familiar with technology. Examples of colored representation of Malaria presence in world using GIS is shown in Figure 4. GIS permits a dynamic link between databases and maps so that data updates are

automatically reflected on the maps. World Health Organization (WHO) posts very frequent updates of Malaria presence and incidents in form of maps as presented in following figure.

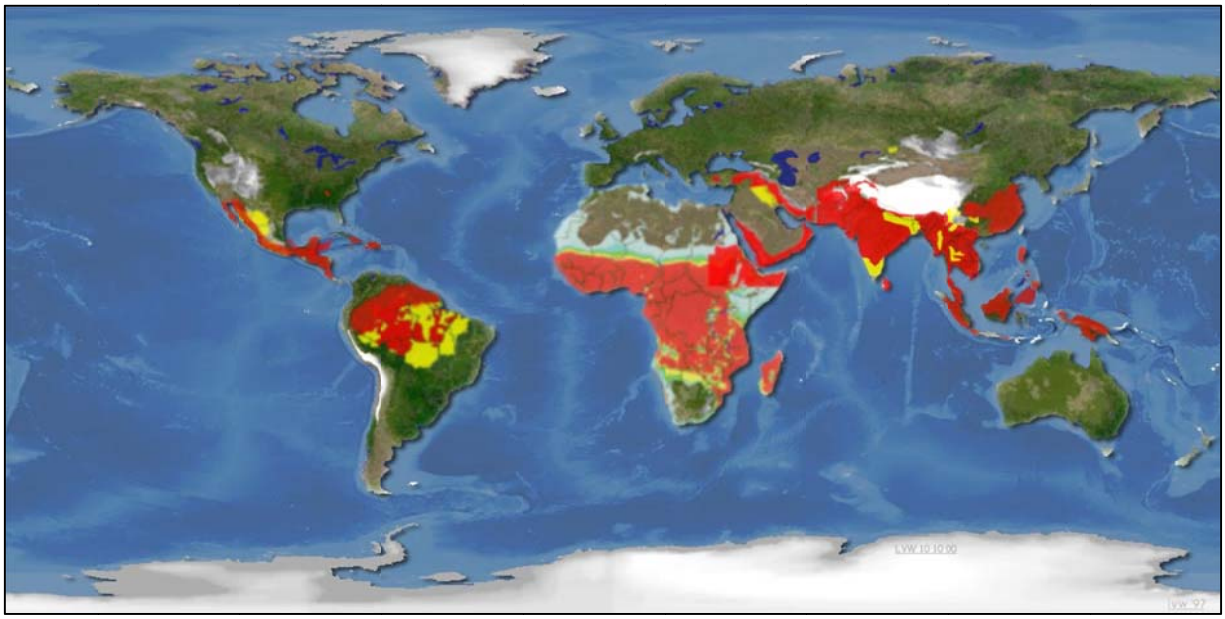


Figure 4: Presence of Malaria in the World. (The Green Man, 2005).

2.3 GIS's Medical Support

2.3.1 Cover/Overlay Analysis

GIS can cover different kinds of information or data. Exposure to variety of different disciplines of data helps in two aspects that are decision making and medical research.

2.3.2 Buffer analysis

Another distinguished feature a GIS provides is that it can create buffer zones around selected features. For example, a radius of 10 km can be drawn around a hospital to represent its covering area or 1 km around a pollution site. Another example shown in Figure 5 is presenting radius of miles of evacuation zones around Fukushima source of nuclear radiation.

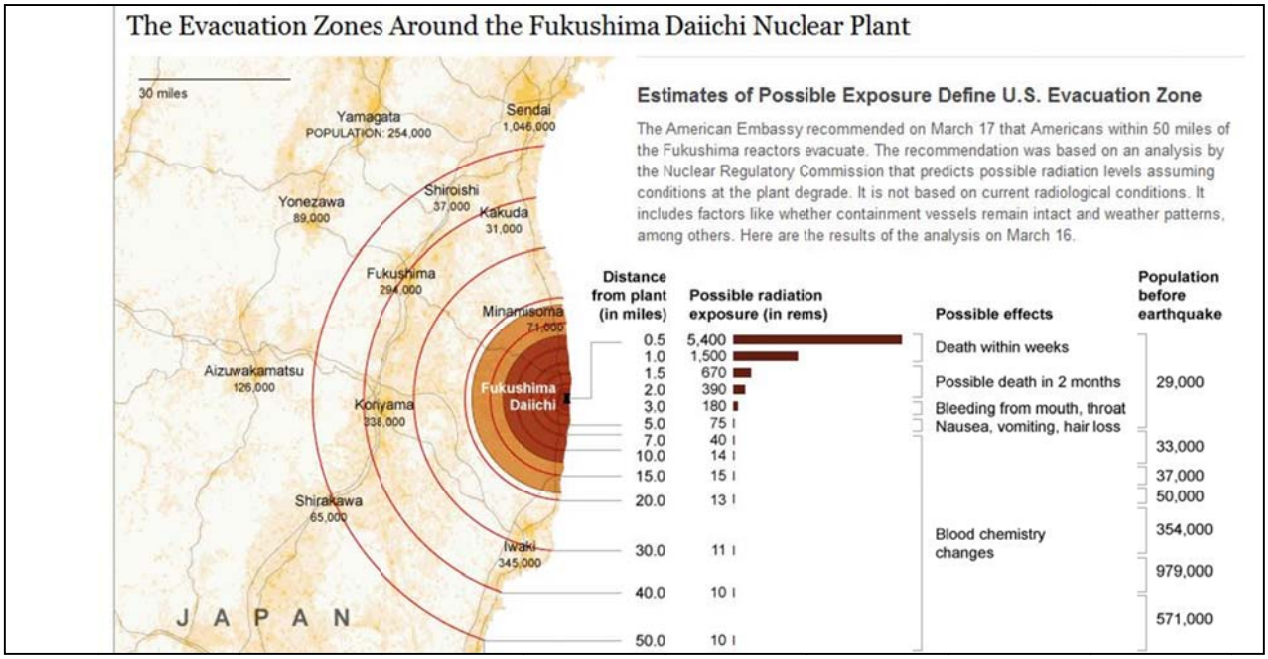


Figure 5: Evacuation Zones around the Fukushima Reactors (New York Times, 2011).

Size of buffer cab be specified and combine this information with disease incidence data to determine how many cases fall within the buffer. Buffer or proximity analysis can be used to map the impact zones of intensity release of radiation sites, where control activity needs to be strengthened. Another example of pasturing zones is shown in Figure 6.

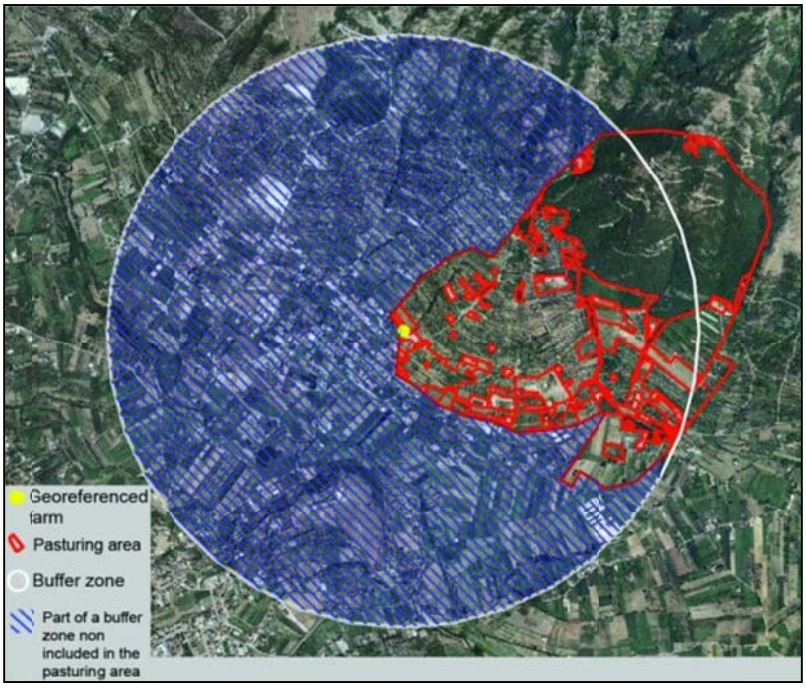


Figure 6: Comparison between a buffer zone and a delimitation of the pasture from which the environmental data can be obtained. (Geospatial Health, http://www.geospatialhealth.unina.it/index.php)

2.3.3 GIS Network Analysis

GIS provides accurate and timely information about where health services are located and instructions with maps on how to get to medical care. GIS provides the ability to quickly access the geo-demographic dynamics of an organization (Ferguson, 2004). It can identify catchment areas of health centers and also locate suitable sites for a new health facility. Health services delivered at public can be scheduled in a more efficient manner by analyzing transportation factors and street patterns and by recommending the most efficient routes.

2.3.4 GIS Statistical Analysis

In performing statistical analysis, GIS can carry out specific calculations, for example, proportion of population falling within a certain radius of a health centre. It can also calculate distances and areas, for example, distance of a community to a health centre, and area covered by a particular health program (Bell, 2007). Figure 7 below shows percentage of water quality in different states at USA.

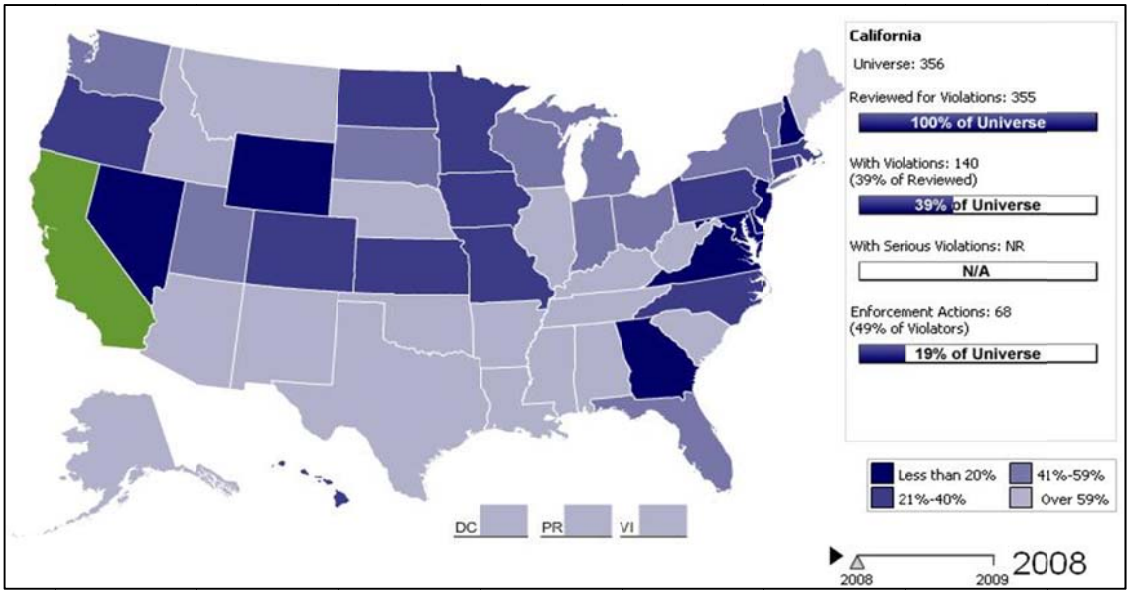


Figure 7: Environmental Protection Agency (EPA) Water Quality Map, (Geospatial World, 2008).

2.3.5 GIS Query

GIS allows interactive queries for extracting information contained within the map, table or graph. It can answer queries of location, condition, trends, spatial patterns and modeling. For example, using previous figure of water quality at different states, a query can be applied on map to get specific information of water quality at each state (Figure 8).

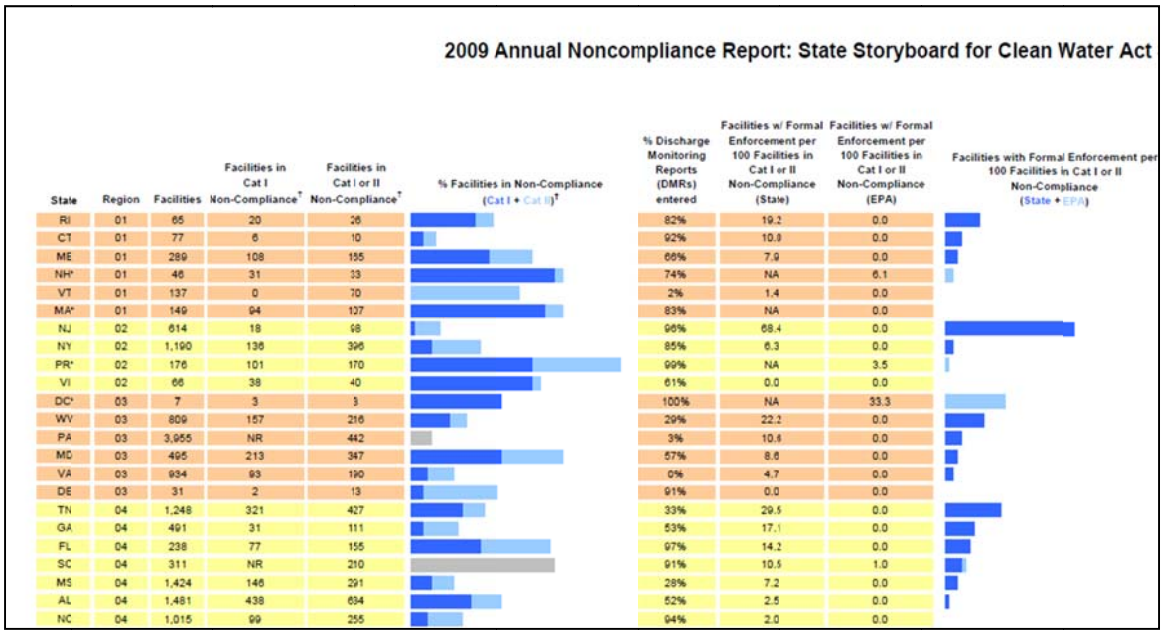


Figure 8: Query at (EPA) Water Quality Map, (Geospatial World, 2008).

CHAPTER THREE: IMPROVED GIS AT HEALTH

3.1 Internet Web GIS

With the revolution of Internet, it assists in the recent advancements in GIS technology in terms of web-based GIS. Several examples are available at the vast Internet. One example is HealthMap.com web site that shows a web based map that displays different disease incidents occurred in world for previous set period of time.

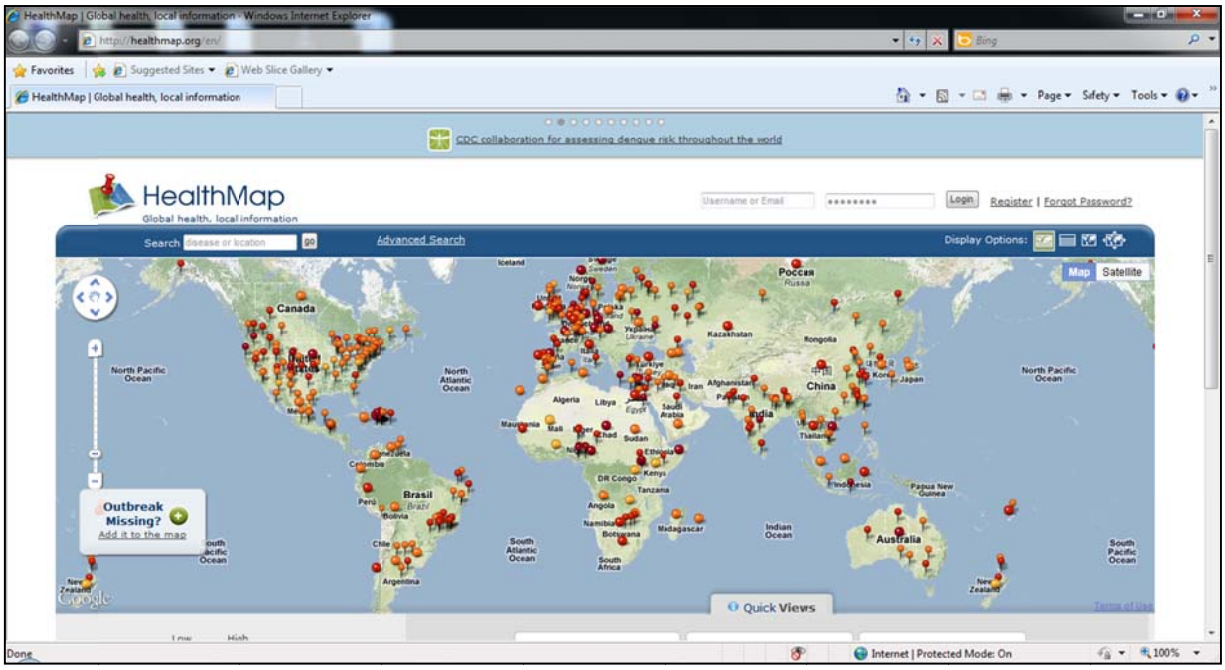


Figure 9: Web Based GIS Map shows Disease Incidents in World, (HealthMap.org, 2011).

Health data is stored in a central server which can be accessed from various terminals connected to the server through internet or intranet. Statistical and epidemiological methods need to be developed to protect individual confidentiality while accessing data. Internet based GIS technology eliminates the traditional method of flow of information, and the information is instantly available across the globe. GIS technology in terms of web-based provide kind of dynamic maps on the Internet to assist patients in locating the most convenient health medical care services quickly and easily.

3.2 Applications of GIS in Health Sciences

GIS has ample ability to support health sciences. Geographic information science, epidemiology, and statistics can provide important improvements in medicine and health research. It can assist in the following professions:

- Public Health Professionals
- Administrators
- Epidemiologists
- Health Researchers
- Health and Human Services Professionals
- Hospital Directors
- Policymakers
- Preparedness Coordinators
- Paramedics
- Community Health Worker (Stoesen, Lyn, 2008).

3.3 GIS and Epidemiology

Knowing the determinants of a disease and its spread from person to person and community to community has become increasingly global (Ezatti, 2003). GIS plays a vital tool in strengthening the whole process of epidemiological surveillance information management and analysis. GIS provides excellent means for visualizing and analyzing epidemiological data, revealing trends, dependencies and inter-relationships that would be more difficult to discover in tabular formats. Public health resources, specific diseases and other health events can be mapped in relation to their surrounding environment and existing health and social infrastructures. Such information when mapped together creates a powerful tool for monitoring and managing diseases and public health programs. (Stoesen, Lyn, 2008). Figure 9 below shows example of Human Immunodeficiency Virus (HIV) or AIDS density in world.

Software packages such as BodyViewer by GeoHealth help medical personnel visualize clinical data. Integration of clinical information is accomplished by linking unique

codes directly to a graphical representation of the human body and to the geographical location where the patient has originated (Ezatti, 2003). Such geo-clinical information system is a useful tool when evaluating environmental risks and exposures. (Stoesen, Lyn, 2008).

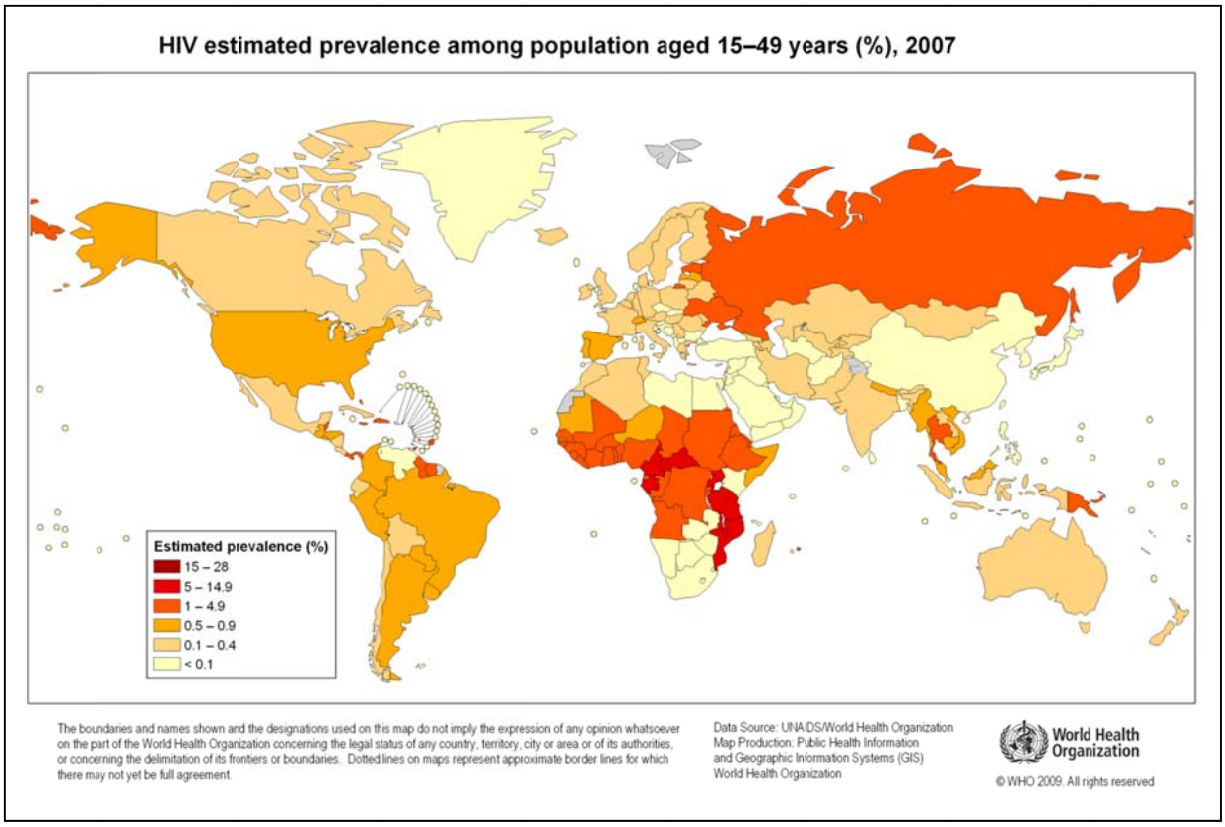


Figure 10: Estimated Incidences of HIV\AIDS Density Worldwide. (World Health Organization, 2009)

3.4 GIS Services at Health

3.4.1 Service Routing

Health services delivered at home can be scheduled in a more efficient manner by analyzing transportation factors and street patterns and by recommending the most efficient route to and from each patient's home. ArcLogistics™ Route software provides a dynamic solution to improve on your existing scheduling and routing method by linking directly to an existing Admission Discharge Transfer (ADT) system (Smith, 2007).

3.4.2 Hospitals and Health Systems

Private healthcare providers and hospitals can capture data, analyze and prepare quality visual presentations in forms of reports and maps for use in product planning, market fore-casting, and more. This field consists of the following units:

- Market Planning
- Strategic Planning
- Marketing
- Research and Evaluation
- Preparedness and Emergency Response
- Population Health
- Point of Service Geo-coding
- Location Services

3.4.3 Managed Health Care

Arranging and paying for healthcare is an important activity in any health organization. GIS provides an efficient way to organize and manage a wide variety of administrative, medical, and social services to patients or clients. Health organizations are using GIS to help their workforce deliver higher client service.

GIS can be applied to manage health care such as: home health and social service case workers, hospital discharge planners, disease management, lab couriers, for getting clients and workers to the right place efficiently has become a business imperative for many organizations. (Stoesen, Lyn, 2008).

3.4.4 Resource Management

Knowing where medical equipment and supplies are located as well as maintaining clinical equipment in a safe condition are functions that require information that can be visualized quickly. Linking the physical location and the condition of equipment and/or supplies in a large plant facility or in a widely distributed medical campus is a powerful new management tool.

ArcView GIS can provide a visual link to other enterprise applications that track resources and their consumption or deployment (Smith, 2007). (Stoesen, Lyn, 2008).

CHAPTER FOUR: CONCLUSION

GIS has ensured its presence and strong participation in easing way of people's lifestyle and living conditions. This support appeared in handy services online and soft wise. Such services represent not limited to track infections, care needs study, health care facilities routes, etc. GIS aids in faster and better health mapping and analysis than conventional methods. It gives health professionals quick and easy access to large volumes of data. It provides a variety of dynamic analysis tools and display techniques for monitoring and management of epidemics/diseases.

GIS has a lot to give now and future. Possible fact is the limitless that is dependent on skill and creative use of researchers and readiness of health sector management to apply GIS vast services.

Comparing with US utilization for example, health GIS in Saudi Arabia has a fertile ground to implement its services such as managing patient care environments and clinical resources; publishing health care information; and presenting clinical data in a visual and geographic form.

Two types of GIS training need to be emphasized when it comes to health GIS implementation. One is system operating and on time maintaining training that shall be considered as main factor of real implementation in Saudi Arabia for example. Second is applying health administrators, professionals, researchers need and user support in GIS technology, data and epidemiological methods in order to use GIS properly and effectively.

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