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Applications of GIS in Health Sciences.

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Abstract:

GIS provides an excellent means for visualising and analysing epidemiological data, revealing trends, dependencies and inter-relationships. It can acquire, store, manage, and geographically integrate large amounts of information from different sources, programmes and sectors. GIS serves as a common platform for the convergence of multi-disease surveillance activities. Standardised geo-referencing of epidemiological data facilitates structured approaches to data management. Once the basic structure is ready, it is easy to convert it to a surveillance system for any other disease. Public health resources, specific diseases and other health events can be mapped in relation to their surrounding environment and existing health and social infrastructures.

GIS helps generate thematic maps that depict the intensity of a disease or vector. GIS can identify catchment areas of health centres and also locate suitable sites for a new health facility. GIS allows interactive queries of information contained within the map, table or graph. It 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.

Keywords: GIS, health, mapping, Epidemics, Management.

Introduction:

Most health and human service problems facing the world today exist in a geographic context and any analysis must consider this. Understanding issues ranging from medical epidemiology to healthcare access requires a comprehensive understanding of their geography. For this reason, GIS is often used because it provides an excellent means for visualizing and analyzing epidemiological data, revealing trends, dependencies and interrelationships. It can acquire, store, manage, and geographically integrate large amounts of information from different sources, programmes and sectors. GIS serves as a common platform for the convergence of multi-disease surveillance activities. Standardized geo-referencing of epidemiological data facilitates structured approaches to data management. Once the basic structure is ready, it is easy to convert it to a surveillance system for any other disease. 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 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.

GIS allows interactive queries of information contained within the map, table or graph. It 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.

Advantages of GIS: 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, programmes and sectors; including epidemiological surveillance, census, environment and others. Surveillance of diseases requires continuous and systematic collection and analysis of data. GIS can eliminate the duplication of effort involved in data collection across an organization, and hence substantially reduce the cost involved in it. GIS serves as a common platform for the convergence of multi-disease surveillance activities. Each data record has to be georefenced to a desired level of accuracy. Standardized geo-referencing of epidemiological data facilitates structured approaches to data management (Brewer, 2002).Once the basic structure is ready, it is easy to convert it to a sur-

veillance system for any other disease, by replacing data of one disease with the data for another disease (O'Sullivan, 2003).

GIS provides access to additional information from a wide variety of sources. Global positioning systems (GPS) can be used to obtain locations of point features on a map, such as wells or septic tanks, 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). High resolution satellite imageries and aerial photographs can be used to obtain accurate and up-to-date maps of any region. Latest, accurate, low cast maps are essential for epidemiological surveillance. Temporal satellite images can be used to monitor land use and land cover changes over time.

GIS Integrates Data; A geographic information system (GIS) is a computer-based tool that organizes and displays data. In health organizations, GIS provides powerful tools for geographic and spatial analysis, and it allows you to visualize data that may have gone unnoticed in spreadsheets, charts, and other reports.

GIS puts information at your fingertips, allowing you to obtain accurate information quickly. By integrating database operations, such as query and statistical analysis, with geographical and spatial visualization, you are able to predict, plan, and recommend interventions and strategies with confidence.

Figure 1: Different type of health organization data

Visualization; GIS offers powerful tools to present spatial information at the level of individual occurrence, and to conduct predictive modeling. It determines geographical distribution and variation of diseases, and their prevalence and incidence. For example, in studying the surveillance of poliomyelitis in India, it is important to find out which type of polio is occurring in which parts of the country, as this has important implications for the disease eradication strategy employed (Longley, 2005). GIS can help in generating thematic maps - ranged color maps or proportional symbol maps to denote the intensity of a disease or a vector (Figure 2). In comparison with tables and charts, maps developed using GIS can be

extremely effective means for communicating messages clearly even to those who are not familiar with technology. GIS keeps track of the geographical locations of service providers, customers, resources, and health plans and programmes, making it easier for policy makers to understand. GIS permits a dynamic link between databases and maps so that data updates are automatically reflected on the maps.

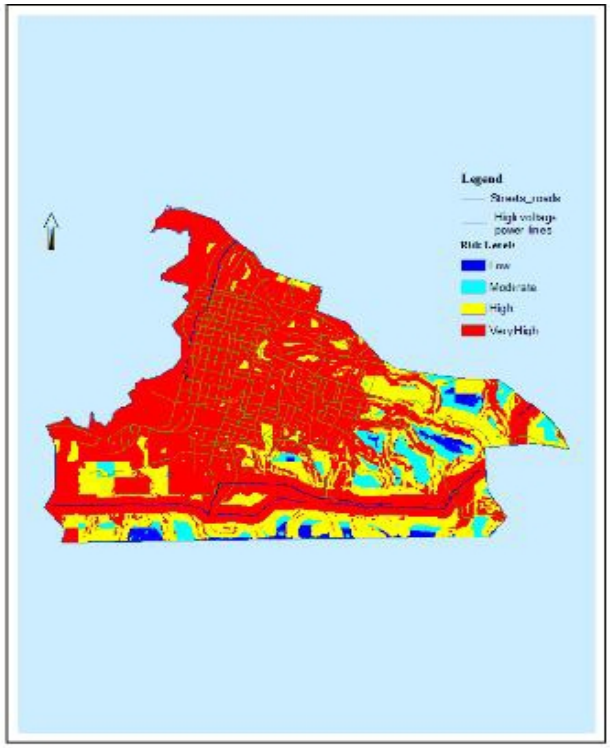

Figure 2: Environmental Health Risks in Port-au-Prince (Maximum combination technique using the Geometric Interval classification method) (Myrtho Joseph, 2007)

Overlay analysis; GIS can overlay different pieces of information. This helps in decision making and medical research through multicriteria modeling (for example, in understanding the association between prevalence of certain diseases and specific geographic features).

Buffer analysis; GIS can create buffer zones around selected features. For example, a radius of 10 km around a hospital to depict its catchment area or 1 km around a pollution site or 5 m on both sides of sewerage to indicate the spread of hazardous material. The user can specify the size of the buffer and then 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 vector breeding sites, where control activity needs to be strengthened.

Network analysis; GIS provides the ability to quickly access the geodemographic dynamics of an organisation's existing service area in contrast to the likely de-

mand for services at a new location (Ferguson, 2004). It can identify catchment areas of health centres and also locate suitable sites for a new health facility. 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. GIS Provides accurate and timely information about where health services are located and instructions and maps on how to get there.

Statistical analysis; GIS can carry out specific calculations, for example, proportion of population falling within a certain radius of a health centre or dam. It can also calculate distances and areas, for example, distance of a community to a health centre, and area covered by a particular health programme or percent of area at-risk by using a classification technique (Bell, 2007).

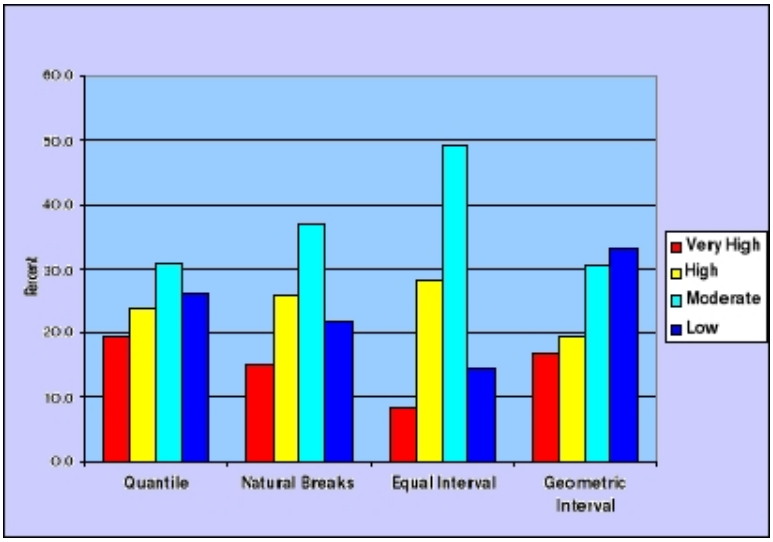

Figure 3: Environmental Health Risks in Port-au-Prince (Percent of area at-risk by classification technique (Myrtho Joseph, 2007)

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 GIS in a first national mapping of functional disability among older American Indians and Alaska natives from the 2000 census (Figure 4).

Extrapolation; GIS provides a range of extrapolation techniques. For example, vector distribution in inaccessible and unsampled areas can be mapped using GIS.

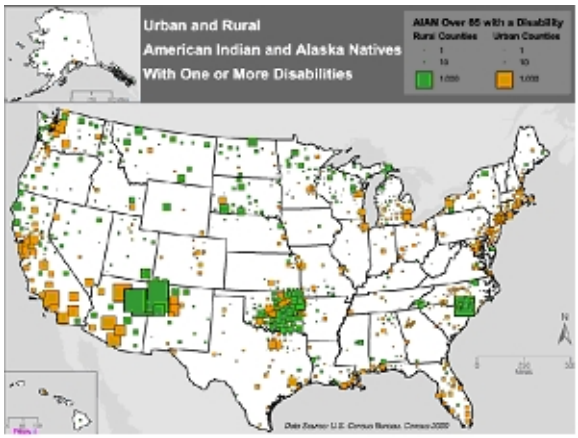

Figure 4: Using GIS in a first national mapping of functional disability among older American Indians and Alaska natives from the 2000 (CDC, September 2006).

Web GIS

One of the recent advancements in GIS technology is web-based GIS. 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. Dynamic maps published on the web allow patients to locate the most convenient services to their home or work easily.

Applications of GIS in Health Sciences

It is obvious that GIS has a lot to offer the health sciences. On the other hand, GIS involves concepts and analytic techniques that can lead to the uncritical use of the technology. Epidemiology, statistics and geographic information science combined can bring important improvements to medicine and health research, and 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

Public Health Professionals; GIS provides a common analytical framework in which public health authorities can understand problems and formulate a response, improving incident management and health planning.

· Disease Surveillance
· Program Evaluation
· Data Management
· Emergency Response and Preparedness
· Epidemiology Research
· Case Management
· Outreach and Promotion
· Administrative Systems using GIS

GIS and Epidemiology; Understanding 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 interrelationships 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 programmes (Figure 5).

The underlying factors that are likely to lead to increases in the incidence of certain diseases, including adverse environmental, behavioral and socio-economic conditions, need to be monitored regularly. By tracking these sources of diseases and the movement of contagions, health agencies can respond more effectively to the outbreaks of epidemics by identifying populations at risk.

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 geoclinical information system is a useful tool when evaluating environmental risks and exposures.

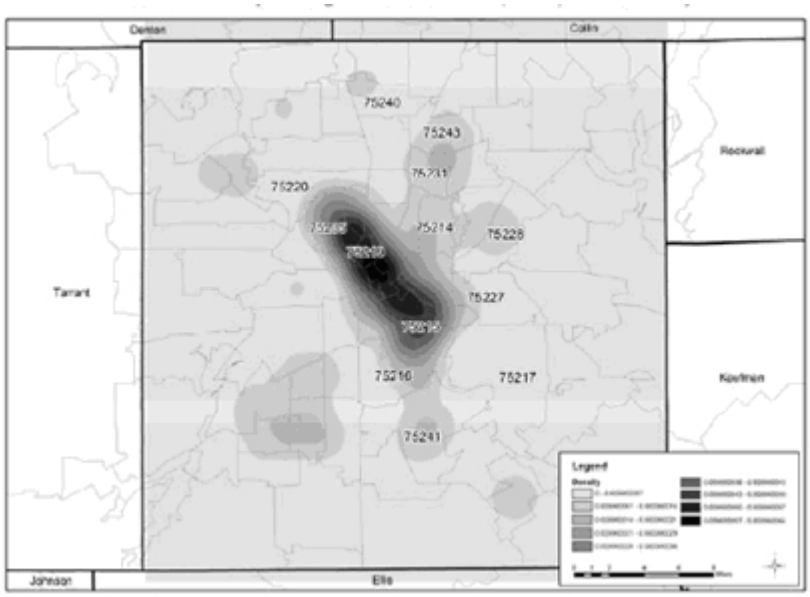

Figure 5:HIV/AIDS Incidence Density among Teens and Youth (13-24) Dallas County 1999-2003(CDC, 2005).

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).

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

Social Services; One of the most important issues concerned by both the public and government in a community is the availability and quality of social services such as childcare support, health care, and housing. In recent years, Geographic Information Systems (GIS) has been increasingly used to assess the adequacy and quality of social services by various government agencies and community organizations (Bell, 2007). GIS helps to reveal the dynamics that underlie the demand, supply, and use of services across space at regional, local and neighborhood scales. The accurate, timely, relevant and clear demographic and social service information have become a powerful tool that enables decision makers to do the monitoring, planning, and evaluation more rationally and effectively. This field consists of the following units:

· Service Planning
· Point of Service Geo-coding
· Case Management (Figure 6)
· Client Tracking
· Location Services
· Data Management

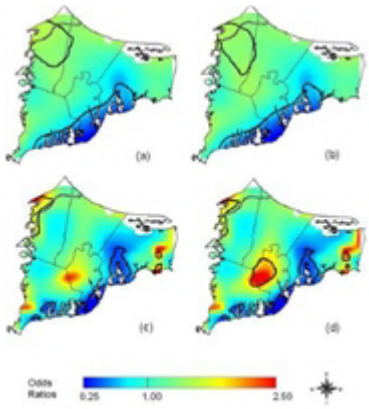

Figure 6: Method for mapping population-based case-control studies: an application using generalized additive models, T Webster, V Vieira1, J Weinberg and A Aschengrau, Int J Health Geogr 5:26 JUN 2006; (CDC, September 2006).

Customer Service; Providing accurate and timely information about where services are located and providing instructions and maps on how to get there is becoming a requirement of good customer service. Putting dynamic maps on the Internet allows patients to locate the most convenient services to their home or work easily. MapObjects® Internet Map Server (IMS) allows the user to publish site-specific information, travel direc-

tions, and maps based on where the caller is located (Smith, 2007).

Site Selection; Identifying a new service location is one of the most basic functions of business development. Having the ability to quickly access the geodemographic dynamics of your existing markets in contrast to the likely demand for services at a new location requires a flexible, yet powerful analytical software tools. ArcView Business Analyst, ArcView GIS, Atlas GIS, and BusinessMAP PRO software all provide varying levels of capabilities for site selection (Smith, 2007).

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. This field consists of the following units:

· Network Management
· Data Management
· Point of Service Geo-coding
· Enrolment Management
· Population Health
· Disease Management

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).

What Is GIS Doing for Health Organizations Today?

GIS technology is powerful and affordable. Its strengths lie in its ability to create access, integrate, and publish large amounts of geographically relevant information. Here are just a few of the ways GIS is working in health organizations today:

· Track infectious diseases and identify gaps in child immunizations.
· Conduct market studies and document health care needs of a community.
· Manage materials, supplies, human resources, and logistics.
· Maintain locational inventories of health care facilities, providers, and vendors.
· Route health care workers, equipment, and supplies to service locations.
· Publish health care information using maps on the Internet.
· Manage patient care environments and clinical resources.
· Distribute clinical data in a visual and geographic form.
· Locate the nearest health care facility or health care provider on the Web.

Conclusions:

GIS aids in faster and better health mapping and analysis than the 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. GIS has a vital role to play in the future. The possibilities that can be explored are limitless, depending on the skill and imaginative use of the researchers and the willingness of health sector management to resource its implementation. Health administrators, professionals and researchers need training and user support in GIS technology, data and epidemiological methods in order to use GIS properly and effectively.

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