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The Utilization of Geographic Information Systems in Healthcare

Zacharias Dermatis[1], Dimitrios Tsoromokos[1], Filipos Gozadinos[1] and Athina Lazakidou[1]

Abstract

Geographical Information Systems (GIS) are integral to the management of health care data, the mapping of health indexes and the impact of a disease. Through the use of GIS we can locate health care facilities, their accessibility and health care needs which may not be available to certain populations. Health care providers can discover new markets and at the same time improve existing services. The acquired data can aid companies and organizations in catalytic decision making, and to formulate new policies. This paper will present various GIS applications in health care. If these applications are implemented they will prove to be an important tool in decreasing the costs of health care, services and supplies.

Keywords: geographical information systems, decision support, healthcare, nosocomial infections, bed management.

1 Introduction

Geographical Information System (GIS) has a wide application in public health and numerous studies have been based on them. Today, in order to deal with various problems in health care researchers are using modern GIS systems and

[1] University of Peloponnese, School of Economy, Management and Informatics, Department of Economics, Greece.

other computer mapping applications. Prediction and simulation models are based on these systems[1].
GIS was used in Connecticut to in order to correlate the relationship between cases that have hepatitis C and intravenous drug users [2]. This is difficult to prove with certainty but the presentation of a relationship between the two phenomena can corroborate this connection, as well as help demonstrate the usefulness and reliability of GIS techniques. Alternatively, GIS techniques have been used to show the lack of correlation between causes and effects or between different results. They have also studied the relationship between birth defects and infant mortality in Iowa, and researchers found no relationship between the two. This led to the conclusion that birth defects and infant mortality are most likely unrelated events, and this is probably due to different causes and risk factors [3].
Epidemiology was one of the fields, which was originally used in mapping health research. Over time, it has become increasingly evident that mapping and geographical information could be very useful and vital not only for research but also for understanding disease processes. This creates a medium for observation and management of diseases and health programs. It is necessary to understand, monitor and emphasize the reasons that can be associated with the development of a disease. Some of these factors could be the environment, behavior and socio-economic level of the region. If the "source" of the disease is recognizable and its development and transmission is known, health administrators will be able to effectively deal with pandemics [4-5]. A GIS system constitutes a tool with great potential that could also contribute to the assessment of environmental hazards and the exposure of humans to them.

During the past decade, GIS applications tended to focus on the following areas:

- in the agricultural sector [6]
- the effects of climate [7-8]
- in medicine and Parasitology [9-11]
- in pesticides [12-13]
- in pollution [14-22]
- in management of wastes [23-25] and
- in wildlife management [26]

The application of GIS in the health sector includes eight main groups:

- travel safety [27]
- environmental health decisions [28]
- health data maps [29]
- the mapping of health services providers [30]
- population growth [31]
- not identify complex disease [32]
- geographic access to health services [33] and
- geographical epidemiology [34]

2 Geographic information systems and mental health

Mental disorders appear to spread in all countries, societies and nations, regardless of socioeconomic level of the population. It is estimated that 20-25% of the population could face a mental illness at some point in their lives [35]. In Greece, mental disorders are common and according to epidemiological studies which are conducted on the general population, have shown that 14-16% of individuals suffer from a mental disorder, with the stress being the most common mental disorder [36,37]. Among all illnesses, mental disorders are one of the most common causes of disability. In addition, they have enormous economic consequences. In recent years, there seem to be new mental illnesses and a high percentage of them typically occur in special populations such as the elderly. Some of these mental illnesses are quite intertwined with environmental changes or disasters and changes in land use such as urbanization [38].

It is expected that the geographical representation of this data will serve as a valuable tool for health professionals both in treating and preventing mental illness. GIS is used to assess accessibility to mental health services and general health services. Geographical factors such as distance can play an important role in the use of these services.For example, proximity to health care services facilitates their use. GIS systems can analyze and accurately represent the distribution of mental health services and to explain the reasons why accessibility to health services is affected. Most often, people who suffer from severe mental illness are forced to relocate to areas that can provide accessible mental health services. Thus, mental health and the course of the disease may be affected due to the fact that a person is required to relocate in order to seek medical care. Therefore, correct and precise positioning aid in having easy access to specific health services [39]. Apart from geographical distribution, other studies on mental health have also used GIS systems. It has been proven that geographical location and easily accessible health services play an important role in the psychologiacal state of the patient [40]. Mental health data on accessibility, mental illness, ethnicity and the level of education of the population that uses these services can be correlated by using a GIS system. All the information and all of the above data is displayed on map [41]. Therefore, it is understood that geographic information systems lead us to understand various aspects associated with mental health. In addition, they help in designing the necessary networks for providing mental health services. These networks must be equally accessible to the majority of the population. It is vital that all healthcare systems worldwide reduce inequalities in health services.

3 Geographic information systems and health services

The design of home care is one of the most active applications of GIS. A geographic information system is able to arrange all the routes to be followed by a healthcare professional while taking into account other parameters. On the other hand, private health services could organize a plan to expand and to promote their services. They can even make predictions for some services that are in high demand in certain areas. In general, the fields of application of GIS could be applied to strategic planning, research, evaluation, preparedness for emergency situations and the availability and location of health care services [42]. Geographic information systems provide a tremendous convenience to health care providers as far asorganization and management of health services is concerned. Therefore, the organization and coordination of the various services will be easier and more effective. The health care provider can quickly and efficiently direct the patient to appropriate health care services [43]. Geographic information systems are able to provide the exact location of specific medical devices and how someone can arrive faster. It is important that an insurance agency be able to know the nearest location for accessing a scan, when requested by the insured [42].

4 The Application of GIS in the management of environmental impacts on health

The use of GIS in environmental issues is very widespread. These systems can be used for both small and simple applications such as analyzing a map and as decision-making tools into more complex issues.

The environmental impacts on human health are significant. According to the World Health Organization, environmental hazards are responsible for about 25% of the total burden of disease worldwide and nearly 35% apply to Africa. According to these findings, 13,000,000 deaths would have been prevented if the environment had been cleaner [44]. Some environmental problems affect human health. GIS could be used in studying cardiovascular health problems, including deaths due to heart disease and stroke. These deaths can be linkedto gaseous pollutants, particularly air pollution. GIS can display these gaseous and particulate matter types and their uniform dispersion and transmission [45].

Water, heavy metals and other chemicals contaminate drinking water around the world. Thus,causing serious health problems due to the fact that water can carry a large number of microorganisms that put public health at risk. The application of GIS, can depict the quality of the drinkable water in a certain area. In addition, these applications could provide additional information about the quality of the water [46].

The terrain and soil contamination can also cause serious health problems. It is very important that the texture of the soil with all additional chemical information be recorded. This is another field in which GIS can be applied [35; 47-49]. GIS can have many applications in the health sector. Varying from simple wooded area depictions to more complex quality of air and water depictions. Many organizations that monitor the environment, and environmental changes and disasters that affect the health of the population, mainly use GIS systems, so as to understand their impact and to promote the health of the population. Over the years there have been numerous environmental surveys using GIS in areas such as the mapping of a disease or to investigate epidemics such as cholera. They can also explore studies on accessibility to clean drinkable water or even mortality by region [50-54].

5 Bed Management System using GIS Technology into Intensive Care Units

Many hospitals in Greece are confronted with capacity problems in their Intensive Care Units (ICUs) resulting in cancelling operations, overloading the staff with extra patients, or rejecting emergency patients. Allocating a vacant bed to a patient is one of the daily challenges faced by hospital staff. To date, the main focus in the development of GIS4ICU has been its application in providing the necessary and sufficient support that is required in bed management. The designed system is a practical, flexible and dynamic tool that aids in the planning and management in the number, type and location of beds which can be allocated to in-patients. The new system is ideal for informed and rapid decision making. Using a geographical format, the data will be displayed in a visual layout, in real-time, and with the exact location of each ICU, bed within a room, ward or floor. Attached patient records for any particular bed would be possible so that they could be examined by those who have the appropriate authorization.

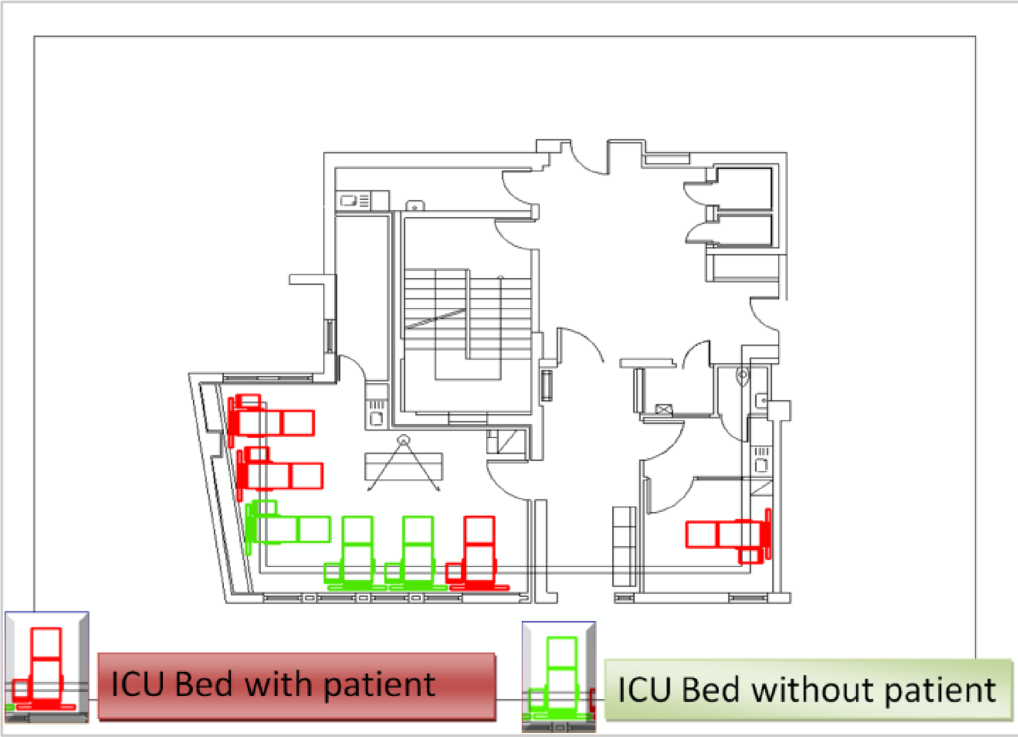

Figure 1. Typical Intensive Care Unit (ICU) with GIS format

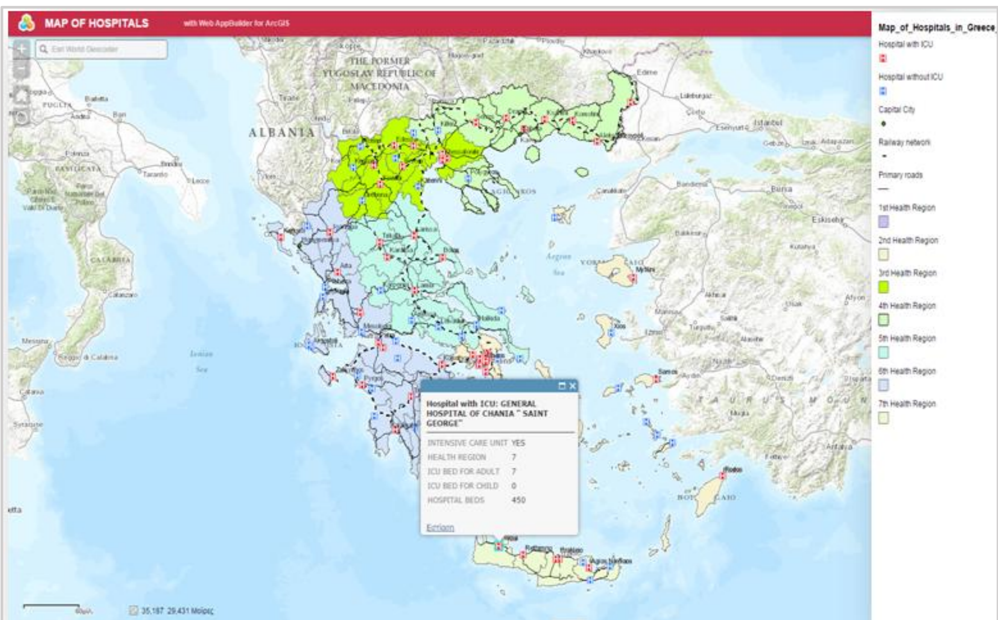

Figure 2. Map of Hospitals in Greece with Web AppBuilder for ArcGIS

GIS technology is associated with health care management and it has the potential to solve the very complex and difficult issues of efficient bed allocation management in order to satisfy relevant health industry protocols.
Hospitals without effective bed management practices face increased staff time in planning and assigning patients to beds in addition to increased costs through alternative placement of patients when beds are not ready or available when needed. Accuracy and efficient use of information is highly dependent on the established patient discharge process and related bed management function. Applying geospatial technology addresses these information needs [55].

6 The Utilization of GIS on Hospital Infections

Nosocomial infections are caused by pathogens that can easily spread throughout the body. Many patients have weakened immune systems thus making it more difficult to fight infections. In some cases, patients develop infections due to poor hygiene in a hospital or a health care establishment, or because the hospital staff did not follow the correct procedures. Some patients acquire nosocomial infections while interacting with other patients, and others come into contact with bacteria, fungi, parasites or viruses by being exposed to contaminated surfaces.
Hospitals around the world are turning to intelligent mapping technology to offer healthcare professionals the opportunity to fully understand and anticipate the needs of patients and the ability to design effective interventions. The new information systems can facilitate hospitals to improve their quality in nosocomial infection control and to safeguard the wellbeing of health care workers and the general public.
The detection of hospital infection in a clinic is particularly important as it may stop it from dispersing. Thus, dispersion and most important limitation is achieved. The information report from the analysis of GIS data helps healthcare professionals to take appropriate measures to ensure patient safety, to improve conditions in the hospital, to properly manage localized outbreaks and prevent future outbreaks. To decision makers GIS is a necessary tool as it has the capability to analyze and direct real-time data, making it possible to investigate the related causes and the spread of hospital infection [56].

7 Description of other Geographical Information Systems in health care

Asthma		
Title	**References**	**URL**
Exposure to traffic related air pollutants: self reported traffic intensity versus GIS modelled exposure	[57]	http://oem.bmj.com/content/62/8/517.short
Examining associations between childhood asthma and traffic flow using a geographic information system.	[58]	http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1566466/
Application of geographical information systems in epidemiological studies exemplified by the ISAAC study in Munich	[59]	http://europepmc.org/abstract/med/11037666
Geographic variations of childhood asthma hospitalization and outpatient visits and proximity to ambient pollution sources at a U.S.-Canada border crossing	[60]	http://ajph.aphapublications.org/doi/abs/10.2105/AJPH.94.7.1250
Myocardial infarction		
Title	**References**	**URL**
Geographical variation in the incidence of acute myocardial infarction in eastern Finland-a Bayesian perspective	[61]	http://www.tandfonline.com/doi/abs/10.1080/07853890310004129
Influenza		
Title	**References**	**URL**
Are influenza surveillance data	[62]	http://www.sciencedirect.com/scienc

useful for mapping presentations?		e/article/pii/S0168170204001091
How representative is the population covered by the RCGP spotter practice scheme? Using Geographical Information Systems to assess	[63]	http://jpubhealth.oxfordjournals.org/content/26/1/88.short
The Use of Geographic Information System (GIS) in the Frame of the Contingency Plan Implemented During the 1999–2001 Avian Influenza (AI) Epidemic in Italy	[64]	http://www.aaapjournals.info/doi/abs/10.1637/0005-2086-47.s3.1010
Severe Acute Respiratory Syndrome		
Title	**References**	**URL**
Towards evidence-based, GIS-driven national spatial health information infrastructure and surveillance services in the United Kingdom	[65]	http://ij-healthgeographics.biomedcentral.com/articles/10.1186/1476-072X-3-1
Viruses of the genus «Hantavirus»		
Title	**References**	**URL**
Study on the application of geographic information system in spatial distribution of hemorrhage fever with renal syndrome in China	[66]	http://www.ncbi.nlm.nih.gov/pubmed/12820941
Bioterrorism		
Title	**References**	**URL**
Initiating informatics and GIS support for a field investigation of Bioterrorism: The New Jersey anthrax experience	[67]	http://ij-healthgeographics.biomedcentral.com/articles/10.1186/1476-072X-2-8

Air Pollution		
Title	**References**	**URL**
Geographic variations of childhood asthma hospitalization and outpatient visits and proximity to ambient pollution sources at a U.S.-Canada border crossing	[60]	http://www.biomedcentral.com/content/pdf/1476-072X-4-14.pdf
Atmospheric Deposition of Polycyclic Aromatic Hydrocarbons to Atlantic Canada: Geographic and Temporal Distributions and Trends 1980−2001	[68]	http://pubs.acs.org/doi/abs/10.1021/es034645l
Climate Change		
Title	**References**	**URL**
Modeling the Hydroclimatic Disturbance of Soil Landscapes in the Southern Canadian Plains: The Problems of Scale and Place	[69]	http://link.springer.com/article/10.1023/A:1006442824787

8 Application of GIS in Healthcare Analytics

For several decades Altarum Institute has used geographic information systems (GIS) to resolve health problems. Through framing the problems of their customers and by understanding spatial influences, The Institute of Altarum excels at helping and understanding their needs. Alturum is applying GIS technologies for health care and more specifically for the following:

- health program evaluation
- operational health metrics
- health market demand analyses and site planning and
- web portals and dashboard

Altarum Institute uses GIS technologies to support and evaluate two health care programs of high importance:
a) health of Veteran Commanders (VHA) and
b) prevention of childhood obesity.

Using GIS technologies, Altarum can determine the amount of time required for Veterans to access services, which is key to the eligibility criteria used within the VHA.

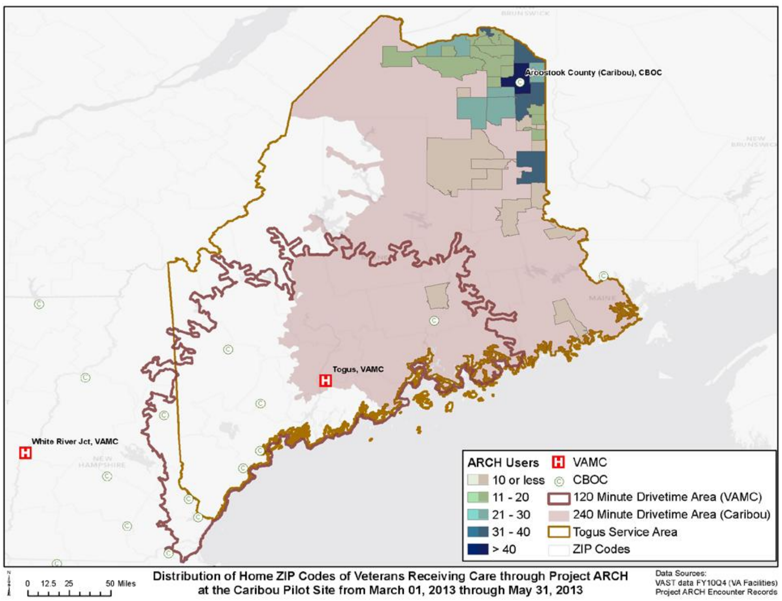

Figure 3. Understanding proximity to health services

Altarum Technologies uses GIS to create maps and export reports in order to assess the program's effectiveness in verifying the location of stores and services, serve the population of an area, low-income population and their difficult access.

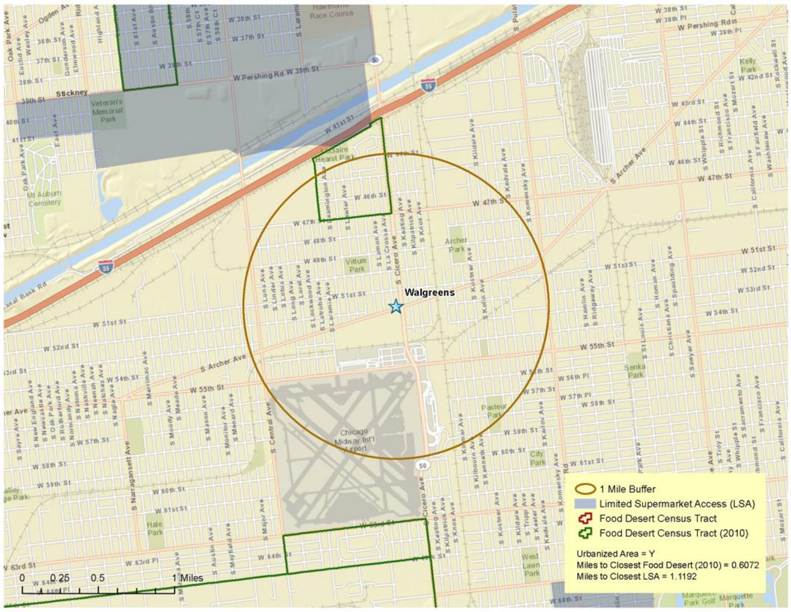

Figure 4. Tracking and evaluating program effectiveness

The use of GIS to map healthcare data is advantageous as it does not obscure important messages which is often the case when reports or tabulations are used.

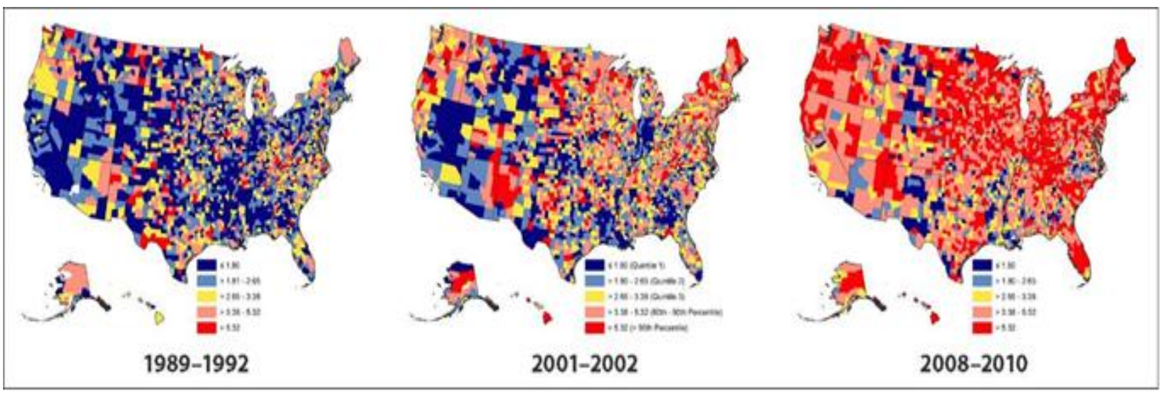

Figure 5. Understanding the geographic progression of disease

Development of advanced Geospatial portals that integrate health data warehouse with advanced GIS applications and tables; which provide constant updated information. To the U.S. Department of Veterans Affairs (VA), VA provides Altarum analysts and administrators with access to intranet GIS mapping, drive time, and other geospatial technologies, applications that embed ESRI ArcGIS Server technology with the SAS Enterprise Business Intelligence data storage capabilities[70].

9 Conclusion

GIS has helped the health care industry manage resources and personnel in the same way that it has helped other consumer service enterprises. Use of GIS for business function- marketing, sales, and facility and materials management will continue to grow. However, in the increasingly information-intensive environment of tomorrow's health care, the role of GIS will have greater importance due to its ability to integrate a wide range of data sources, from legacy systems to image data, and to make complex data more quickly and easily understood.

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