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## REVIEW

# Health Based Geographic Information Systems (GIS) and their Applications

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### ABSTRACT

Medical researches as well as the study of the Earth's surface, better still, geography are interlinked with each other; their relationship dates from antiquity. The science of Geographic Information Systems and, by extension, Geomatics engineering belongs to a discipline which is constantly developing at a global level. This sector has many applications regarding medical / epidemiological research and generally, the social sciences. Furthermore, this discipline may act as a decision making tool in the healthcare sector and it might contribute to the formulation of policies into the healthcare sector. The use of GIS so as to solve public health issues has an exponential increase and has been vital to the understanding and treatment of health problems in different geographic areas. In recent years, the use of various information technology services and software has lead health professionals to work more effectively.

**Key words:** Geographic Information Systems, applications, medical research, public health.

## 1. INTRODUCTION

Medical researches as well as the study of the Earth's surface, better still, geography are interlinked with each other; their relationship dates from antiquity. Hippocrates was the first to describe the relationship between the geographical characteristics of a place and the inhabitants' health. Hippocrates described all these in his treatise "On Air, Water and Places". [1] As the time goes by, it has become increasingly apparent that the mapping and the geographic information might be both very useful and vital not only for research but also for understanding the processes of diseases. The study of the English Physician John Snow in 1854 was a milestone towards this direction. It led to the detection of the source of infection in a cholera epidemic that broke out in London. Having mapped the locations of those individuals who were affected, he concluded that contaminated water was the cause of the outbreak. [2] This research laid the foundations for both cartographic and geographic applications as a tool in medical science. Nowadays, the rapid development of technology has resulted, among other things, in the creation and deployment of new disciplines that cooperate with both the science of medicine and medical research. The science of Geographic Information Systems and, by extension Geomatics belongs to a discipline which is constantly developing at a global level. This sector has many applications regarding medical / epidemiological research and generally, the social sciences.

## 2. PURPOSE

The purpose of this study is to highlight Geographic In-

formation Systems as technology and the various applications that they find in the field of medicine, either epidemiological or social research and health care, in general. Furthermore, this discipline may act as a decision making tool in health care and it might contribute to the formulation of policies regarding the health sector.

## 3. MATERIAL AND METHODS

The method of literature review was used in this study. It also included articles and publications that are related to the theme. What is more, this study has drawn information on researches and publications that are taken from databases such as HEAL-LINK, Google Scholar, Pub-med material. The Key words that were used in the search were: Geographic Information Systems, Applications, Medical research, and public health.

The literature review was conducted between March and August 2014. Finally, 32 articles and publications were chosen from the initial 187 articles and publications. That happened after sorting out the material which was mainly based on abstracts and their content.

## 4. DEFINITION OF GEOGRAPHIC INFORMATION SYSTEMS

The first maps were made due to the fact that people needed to classify the special elements of the earth's surface. These elements relate to spatial distribution as well as the demand for specialized maps regarding the earth's surface. The rapid development of information technology and the extension of

the concept of data have led to the need for the creation of electronic maps. Geographic Information Systems came as a natural evolution of cartography.

Geographic Information Systems (GIS) are spatial data management systems. These data are associated with respective geographic features. They are digital systems that can integrate, store, adjust, analyze and arrange geographically-referenced information. Generally, they could be described as smart maps that offer a simulation of the real world to their users. They can also generate interactive spatial or descriptive questions (research that has been created by the user), analyze spatial data, adapt and adopt them in analogue (prints maps and diagrams) or digital media (records of spatial data, interactive maps on the Internet). [3]

The function of GIS is based on a database which may be used by different users in order to meet various information needs. This database consists of a series of information layers, which refer to the same geographical area. Each of these layers contains either raw data such as topographic or satellite data or thematic data such as health services. All these are strictly oriented towards a common geographic system so as the combination among some of them to be possible according to the user's needs. Geographic Information Systems can convert spatial data into the Geographic or Cartographic or Cartesian coordinate system. A key feature is that spatial data are related to descriptive data. For example, a group of points that represent different areas of different cities that are connected by a table, in which each record except for the exact location, contains information such as name, population etc. Such systems provide pieces of information regarding the data that are associated with the location for their collection, management, storage, processing, analysis and visualization in a digital environment. These data are usually called cartographic, geographic or spatial ones. Moreover, they may be associated with a series of descriptive data which characterize them as unique. [4-6]

#### 4.1. Brief historical retrospect

As it was mentioned above, the human need for information about spatial distribution as well as the demand for specialized maps relating to the earth's surface has led to the development of GIS. The maps which were created to meet this need were the first form of GIS. Over time, the methods for the creation of soil maps are enriched with the aerial photography, remote sensing images and their analysis. As a result, there seems to be more detailed mapping that offers not only a huge potential towards research but also a significant increase in accuracy of the results arising from it to the scientific community. [7]

As the time goes by, and during the 60s and 70s in the U.S.A, several designers, architects and generally, scientists whose work was inextricably linked with the ground tried systematically to use cartographic data. In fact, they led to the conclusion that data that are obtained by primary research can be unified and combined with transparent maps on light sources. Additionally, Howard T. Fisher, in 1963, was the first man who created SYMAP (Synagraphic Mapping System) and thus, he attempted to introduce geographic / cartographic data in the H / Y. This program was able to reproduce maps and it could also print them. The progress in the field

of information technology has led to the continuous creation of advanced programs regarding this field. So, programs such as GRID and IMGRID were designed after the creation of the SYMAP program in order to reach the recent generation of programs which is called Geographic Information Systems (GIS). Those systems are able to analyze and present information from various geographical areas. These programs have been used by scientists of different fields that are constantly rising. [7-8]

#### 4.2. Features and applications

The development of GIS over time is proportional to the wide general development of the computer science. The development of Geographic Information Systems has advanced the geographical information systems as we know them today. Geographic Information Systems (GIS) are a set that consists of equipment, software, databases which contain a satisfactory collection, storage, information, management, analysis and presentation of all types of geographic information. GIS could be used as decision-making tools for various problems involving spatial data. GIS can be applied in various sectors such as transport, telecommunications, public utilities, environmental design, and health services; additionally, domains such as Country Planning, Geology, and Soil and Forest science may utilize GIS. [9, 10]

#### 4.3. Geographic Information Systems (GIS) and public health

The public health sector is a very complex and controversial field. Professionals who are interested in this domain should have critical understanding as regards the correlation amongst factors that affect health. In recent years, the work of health professionals is constantly becoming more and more effective owing to the use of both various information technology services and software. There are much more problems and challenges in relation to the public health sector than Dr. Snow faced in 1854 when he introduced mapping in medical research. Recently, the use of GIS and spatial representation of various health issues make professionals arrive at conclusions in a faster and better way in the field of both public health and decision-making. [11]

The use of these systems has a wide impact on the public health and lots of studies are based on them. Prediction as well as simulation models rely on these systems. Additionally, risk assessment models in relation to the contamination of drinking water in London are based on them. [12] Aside from this, other researches that focus on Hepatitis c and intravenous drug use have been displayed with the aid of GIS. [13]

Besides, GIS can contribute to public health in many ways due to the fact that they can provide information on many issues and support correctly the decision making process. They can provide information regarding the distribution of health services. Thus, any growing disparities might be eliminated. Also, policy-makers would make right decisions. Health professionals can easily identify the difficulties and disparities regarding the accessibility to health services; and so, they are able to cope with the current situation. Generally, the planning of health and social care is of major importance since it is a fundamental issue. At the dawn of the 21<sup>st</sup> century, in the midst of remodeling the entire health care system, the use of new approaches relating to health issues may become useful

tools for the providers of these services. The use of GIS as public health issues to be solved has grown exponentially. Those systems have been vital to both the assessment and treatment of health problems that relate to different areas of land. [14]

As it was mentioned above, epidemiology was one of the fields, in which maps were firstly used on health research. It is essential we be able to understand a disease and how it spreads through human-to-human transmission.

A Geographic Information System can play an important role as regards the surveillance, management and analysis of diseases. There seem to be important tools for analysis and visualization of epidemiological data. Furthermore, trends and correlations would be difficult to be understood with traditional ways of processing and imaging of these data. [15] Public health services, diseases, and any information regarding health can be displayed on a map and correlated amongst many pieces of information such as environmental data, elements of health concern and social information.

Thus, it is created a means of monitoring and management of both diseases and health programs. It is necessary we be able to understand, monitor and emphasize on the reasons that may be correlated to the development of a disease. Some of these factors could be the environment, conduct and the socioeconomic level of an area. Should the “source” of a disease be identifiable and its development and transmission are known, health administrators will be able to deal effectively with pandemic outbreaks. [15, 16] A GIS is a tool with great potential that might also contribute to the assessment of environmental risks and people’s exposure to them.

#### 4.4. Geographic Information Systems and mental health

Mental disorders appear to be spreading across all countries, societies and nations regardless of the population’s socioeconomic level. It is estimated that 20–25% of the population will face a mental illness at some point in their lives. [17] In Greece, mental disorders are common and according to epidemiological studies, which are carried out regarding the general population, pinpoint that 14 to 16% of individuals suffer from a mental disorder; stress is the most frequent one. [18, 19] Mental disorders are one of the most common causes of disability among all diseases. Moreover, they have enormous socioeconomic impacts. In recent years, there appear to be new mental diseases and a high rate of them usually appears to specific 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. [20] It is manifested that the geographical representation of these data would be a valuable tool for healthcare professionals to both treat and prevent mental illness. The accessibility of mental health services as well as general health is one of the most common types of research that is based on GIS. Geographical factors such as the distance may have an influence over the use of mental health services and the long distance between healthcare systems and patients reduces the rate that patients used to visit to these departments. GIS can analyze and portray accurately the distribution of mental health services and they could explain the reasons why the accessibility in healthcare services is affected. More often than not, people who suffer from a serious mental illness are

forced to relocate to areas that provide mental health services which are more accessible to them. On the other hand, such changes alone have a huge impact on mental health and the course of the disease. Therefore, the right and accurate arrangement of these services helps in order accessible services to each and every person to be both developed and designed. [21] Except for the geographical distribution, other studies on mental health have also used GIS to correlate mental health and geographical variables such as the individual’s residence. [22] Mental health data regarding accessibility, mental illnesses, ethnicity and educational level of the population using these services can be joined together by GIS. Thus, all the pieces of information and all the data above are shown on a map. [23] All in all, it is obvious that Geographic Information Systems lead us to understand various aspects that relate to mental health and its maintenance. Additionally, it helps networks that provide mental health services to be designed. These networks must be equally accessible to the majority of the population. It is vital all health systems around the world decrease health inequalities.

#### 4.5. GIS and healthcare services

The planning of domiciliary care provision is one of the most active applications of GIS. A Geographic Information System is able to organize all the routes that a health care professional has to follow and it can take into account other parameters, too. On the other side, private health services could arrange their extension plan and promote their services. They even make predictions about some services that are in great demand in specific locations. Generally, GIS application areas might be applied towards Strategic Planning, Research and Evaluation, emergency preparedness and both response and location of health care services, too. [24] Geographic Information Systems provides a tremendous convenience for health care providers as regards the organization and the management of these services. Hence, the organization and coordination of various services would be easier and more efficient. The healthcare provider may direct quickly and efficiently the patient to suitable health care services. [15] Geographic Information Systems provide us with the exact location of specific medical equipment and how somebody may gain the fastest access to it. It is important an insurance institution, when it is requested by the insured, know the nearby location where the insured could gain access to a CT scanner. [24]

#### 4.6. The application of GIS in environmental health management

The use of GIS in environmental issues is widespread. These systems can be used as small and simple applications such as a map analysis as well as decision-making tools to more complex issues.

The environmental impact on human health is important. According to WHO, environmental hazards are responsible for about 25% of the total burden of disease worldwide and nearly 35% applies for Africa. What’s more, according to WHO 13 million deaths would have been avoided if our environment had been healthier. Some environmental problems that affect human health and, in which GIS could have been used are:

Studies have shown that cardiovascular events, including heart and stroke deaths are associated with gaseous pollutants

and especially with air pollution. GIS can display gaseous pollutants and particulates and even their dispersion and transport.

Water, heavy metals and other chemicals pollute the drinking water worldwide. Thus, serious health problems are caused due to the fact that the water can carry a number of microorganisms which put equally the public health at risk. Similarly, the applications of GIS, here, can depict the drinking water by region. Also, these applications could provide some additional information about the texture of the water.

The ground as well as soil contamination might also cause serious health problems within a population. It is very important the soil texture with all the additional chemical information be recorded. This is another field in which GIS have found application. [25; 27]

There seem to be lots of examples that may be employed; they vary from simple forest imaging to complex depictions of air and water quality. Many agencies, which supervise the environment as well as environmental changes and disasters that have impact on population's health, use primarily GIS so as to understand their repercussions and promote health of the population. These agencies promote the use of such systems to operate effectively regarding monitoring, restoration and planning policies in development even in safeguarding the environment. As time goes by, a lot of environmental researches have been carried out using GIS in fields such as disease mapping, investigation of epidemics like cholera; areas under investigation where appear high rates of spontaneous diseases. Also, studies regarding accessibility to clean drinking water or even mortality rates by region may be explored. [28-32]

## 5. CONCLUSIONS

Technological advances keep up with medical advances. Their common and consistent goal is to secure human existence. We can say with absolute certainty that Geographic Information Systems are important tools in relation to the investigation of health sciences and they have many applications. These systems enable health-related information to be displayed. Hence, the multidisciplinary work is more efficient. Geographic Information Systems enable the visualization and monitoring of infectious diseases. Additionally, these systems record and display the health care needs of the community as well as the available resources and materials.

**CONFLICT OF INTEREST: NONE DECLARED.**

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