GIS Applications in Public Health as a Decision Making Support System and It’s Limitation in Iran

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Abstract: One of the most important indices of defining general welfare and quality-of-life of people in the world is physical and mental health of individuals. Much of causing factors of the diseases are essentially spatial; i.e. their distribution and concentration vary in different locations. Therefore, GIS can be used as a decision support system in order to help the managers of public health. In recent years, many applications of GIS in public health are developed that include management of available health resources, prediction, simulation and management of epidemics and monitoring and control of diseases. On the other hand, time plays an important role in health affairs especially in the time of disasters. Therefore, access to useful spatial information and making proper decisions, based on analyzing such information, will facilitate reaching desired results in shorter time and less cost. In this article, it is tried to study and evaluate the experiences on applying GIS in public health. Then, obstructions and difficulties of using GIS in decision making concerning public health, in special situation of IRAN, are examined and some suggestions are proposed to overcome such problems. Finally, two applications of GIS in public health affair are implemented using the data related to the death counts caused by cancer in Iran.

Key words: GIS · Spatial Analyses · Public Health · Disease Control · Decision Making

INTRODUCTION

Nowadays, health and health care are considered as an important factor in the quality of life of individuals. In fact, the development of public health and diseases management plays a significant role in cultural, social and economical development of any society. The most important goals of each public health organization involve environment health, control of diseases, health education and prevention, medical and nursing actions for early diagnosis, control and management of diseases [1]. Many interrelated changes in the world such as urbanisation, transportation and industrial development, population and life expectation growth, unsustainable agricultural development, etc. cause general and complex environmental problems that threaten the health of humankind seriously.

Dealing with such a complex and multi-aspect problem can not be on the basis of common sense and managing experience of the decision makers in public health area. In fact, up-to-date information and adequate models are required to help them to decide regarding any of the parameters affecting public health.

Both human settlements and activities and factors causing human diseases spread geographically. Most of pathogenic factors are universally epidemic and do not belong to a special region or area, while some of them just occur in specific regions [2]. Usually, concentration of a disease in particular areas statistically indicates the unusual presence of some factors that cause the disease. Moreover, the co-occurrence of such factors in an area increases the happenings of the disease dramatically. Such correlations make it necessary to study and compare the spatial distribution and pattern of both the diseases and their assumed factors. Geographical information system (GIS) can be used to analyze and compare such patterns.
Having the technological improvements, especially in the ease of access and user friendliness of GIS software, users increasingly find out GIS capabilities and tend to make their decisions on the basis of information provided by GIS.

**Experiences of Using of GIS in Public Health:** More than 150 years ago, public health experts realized the use of maps in analyzing the location of the disease-related happenings. In 1840, Robert Cowan in Glasgow-England, used maps to show relationship between crowd and incidence of yellow fever. He recognized that in regions where there is too much immigration, this disease was more epidemic. Also in 1843, he showed epidemiologically incidence of typhus on a map which involved all of the infected houses [3].

Since then, GIS have been continuously used for the analyses of spatial health related data. During this period, the more GIS analytical capabilities were developed, the more advanced and comprehensive spatial models were developed by the collaboration of experts in both areas of GIS and epidemiology and health care.

Nowadays, especially in the new century, different GIS applications or modules for health care applications have been designed and accomplished in many countries. In the followings, some experiments in applying GIS for public health affairs are discussed. Malaria was studied and modeled, in Amazon area, using GIS in international research development center of epidemic diseases. Aims of this study were: comparing risk of being affected by Malaria in different social groups and in different environmental condition, studying effects of social and economical factors on prevalence of disease, understanding influences of environmental and economical factors on disease and perceiving general situation of Amazon agricultural regions from viewpoint of prevalence among people. Finally, GIS and statistical software and data were used to study the relationship between different factors and Malaria [4].

In 2002, Office of Statewide Health Planning and Development (OSHPD), in California USA, established a powerful system for resource and facility management. In this project, using the results of need analyses, the conceptual model was designed. In the next step, classes, subclasses and available relations and so on was defined in software. Then, the collected data was entered and the final system was created to respond to the desired requirements [5].

In 2002, a project in Karnataka was accomplished for dividing regions and specifying local domain of health area responsibility. Reason for performing this study, was referred to the disproportion between population of region and location of health center. Final goals were to control and supervise health center operations in their responsibility region, to optimize use of available health resources and to cover clients’ needs. Related data to service area of health center had been provided by PHC and SC institutes for all sections and regions. The result was a GIS with the ability of performing special analyses, such as: zoning regions, finding the best location for facilities [6].

In 2002 in Ayuthaya, Thailand, GIS was used for examining effects of different factors on public health, showing disease distribution, performing specific analyses, visualization and providing of information on health care and also helping in different decision making. Data used in this study include: population data, data concerning infectious diseases and their occurrence locations. In this study, dependence of spreading disease on time was studied using statistical regression analyses. One of the advantages of this study is the simultaneous use of spatial and statistical analysis which provides powerful tool for decision making process. Among all examined diseases, pneumonia had a direct relation with time and highest dependence coefficient (94 %) and its distribution in crowded areas was high [7].

In 2003, Eastern Europe international health organization started to estimate diseases as a result of water pollution by means of GIS to specify pollution resources and direction of occurring diseases. In this research, primary studies determined system requirements for managing and taking care of disease and also factors that cause them. Then, some of disease intensifying factors and data related to them was gathered. Finally, GIS was used as a managing system to store and recover data, display and recognize temporal and spatial association of disease [8].

In 2006, a project was accomplished by environmental conservation organization in order to control WN virus, in Pennsylvania, USA. This virus could spread easily and quickly in every environment. In this study, GIS was used for gathering and combination of data from different resources and for creating a central geo-database to provide relation between different data centers. Environmental sampling was accomplished by means of dynamic GIS technology and wireless GIS. In the resulted system, users could determine prevalence direction, extent of spreading and number of affected people [9].
Using of GIS as a Decision Support System for Public Health Management: GIS can be defined as the science and technology related to the gathering, storage, manipulation, analysis and visualization of geo-referenced data. Using a GIS, we can combine different data and generate information required for decision making. In the followings, we describe the more important aspects of public health and explain how GIS and spatial data analysis can be used for any of those aspects.

Management of Environmental Pollution and Public Health: As already mentioned, in recent decades, the population growth and unsustainable industrial and agricultural developments degrade the long-existing environmental balance of the globe. As a result, the human's life environment becomes more polluted and fragile. Through the air, water and food consumed by them, people are exposed to many toxic and health damaging materials that directly or indirectly degrade their health.

GIS can be used first to map such pollutions and environmental damages, then to compare and overlay them with the locations of water resources, cultivation area and human settlements. The results can be used by public health managers to decide where to expect health damages and where to concentrate their environmental protection policies and activities.

Disease Monitoring and Control: Even in normal situations, still, most of the diseases can occur in human societies. However, always, there are policies, regulations and activities that can help in preventing or lessening of disease occurrences.

The first step in making such activities possible is to map and monitor the time and location of disease happenings. Usually the spatial data collected are either in the form of points representing the location of individual patients or the settlements along with other attributed data, or in the form of polygons representing regions or urban districts along with disease statistics and other attributed data. In a GIS, using such geographical data and the linked statistical and attribute data, many thematic maps can be generated that directly guide the managers towards better and information-based decisions.

The relationship between diseases and their causing factors can be modeled using geo-statistical methods and techniques. Using such models, decision makers can prioritize not only the affecting factors of the disease, but also the actions and regulations required for fighting the disease. Even, the generation of different scenarios and evaluation of the results of different terms of actions can be carried out.

Epidemiology and Health Related Disaster Management: A critical aspect of public health management involves the prediction, modeling, prevention and management of epidemic. In this regard, three basic factors that should be considered are: time, place and patient [10-12]. Therefore, taking factors of space and time into account for studying public health and epidemics are necessary.

Causative factors of many diseases change by time. Moreover, the transformations of infectious diseases are quite related to the movement and traveling of people or relevant vectors. Therefore, the role of time in monitoring and modeling of the diseases should certainly be considered.

Researchers increasingly try to find factors that causes or ease the transfer of infectious diseases and to model the way they spread in environment. Environmental factors and even culture and life stile of people in a specific region may change the speed of disease spread. By tracing the spatio-temporal distribution of such factors, the direction and speed of the disease spread can be modeled. Using such models, health decision makers could predict the progress of epidemic and have quick and suitable response to it. They can identify the location and number of infected individuals and location of people who are at risk.

Another component of epidemic management is a system of information dissemination and alerting. Preparedness of the local experts, authorities and, more importantly, the people themselves is a key factor in challenging an epidemic. GIS permits health affairs experts to combine data from different sources, perform different spatial analysis on the data, show the results on a map and publish their information and maps on internet or local networks.

Implementing Some Practical Applications of GIS in Public Health Management: As practical applications of GIS in public health management, two examples are provided, related to the monitoring and control of cancer disease. In the first example, GIS was used for detecting the clusters of four types of cancer. In this study, first, different geostatistical methods for the analysis and visualization of spatial distribution of cancer were tested and compared. The comparison showed that probability mapping is the most suitable method for detecting and monitoring spatial clusters of these types of cancer. Such
clusters represent the areas where the occurrences of the disease are statistically significant and meaningful. Finally, probability mapping was used for analysing and visualising the statistics of death caused by lung cancer, stomach cancer, leukemia and skin cancer in 18 provinces of Iran. Based on the gathering of the death records, the township was selected as the spatial unit of this study.

For example, the result of probability mapping shows that significant occurrences of lung cancer are clustered in the central and north-west part of the country, as shown in Fig. 1.

In the other study, GIS was used for the development of a geostatistical model of skin cancer. The model represents the causing relation between the occurrences of the disease and some parameters, that apparently have important causing effects on the disease. Having developed such a model, we not only can determine what parameters cause and increase the happenings of the disease, but also can calculate the exact importance and significance of each parameter. Moreover, in such a geo-statistical model, we could extract the interactive effects between parameters caused by their correlation.

In addition, the model can be used as a simple spatial decision support system for predicting the results of any course of action. In other words, by assuming different scenarios of changes in the parameters of the disease, the managers can predict their effects in the amounts of the disease in various locations. Such changes in the parameters can be used for planning the challenge against the disease. This means that the budget, personnel, equipment and time can be allocated much more efficiently for reducing the happening of the disease.

In the modeling process, study of the spatial distribution of both the disease and its parameters is the most important aspect of the model development, which justifies the use of geostatistical modeling approach and application of GIS in all stages of data manipulation and analysis.

The model showed that the main parameters causing or effecting skin cancer, in order of significance, are temperature, atmosphere pressure, interactive effect of bright sun shine hours and solar energy, solar energy, bright sun shine hours, ratio of farmers count to the whole population, fruit and vegetable consumption, contact with lead, potassium fertilizer and tobacco consumption.

**Limitations of Using GIS and Spatial Data for Public Health in Iran:** Recently, in Iran, first steps in the application of GIS in public health management have been taken. However, much more effort is needed for the proper usage of GIS and spatial data in the management of public health and disease control.

In the followings, the main obstacles and limitations in this regard are summarized:

- In many governmental organizations, the role of location in gathering data is not recognized properly. In other words, the data are collected either completely without recording the location, or only mentioning the geographic name of the place. In both cases, huge amount of extra work is required to collect and add the location element to the data.
- Usually, a variety of data from different organizations are needed for managing any of the above-described aspects of public health. Often, the lack of cooperation between those organizations and limited access to their data makes the developed disease and health models unrealistic and unreliable.
- The data about the disease occurrences are limited to the death accounts reported by hospitals; i.e. the cured patients are not recorded. As a result, the reported records of death caused by a disease are not a good representative of the real happenings of that disease.
- Often, the location where patients live and get ill is different and even away from the place of the hospital, where their death is reported. This decreases the positional accuracy and general acceptability of the geo-statistical models representing the relation between the diseases and spatially distributed factors.
- One of the parameters affecting disease occurrences in individuals is their eating habit and life style. Unfortunately, rarely, data about these are registered with acceptable spatial unit. The available data in
national scale include sample-based data on family
spending habits in cities and villages. The smallest
spatial unit in these data is province. If these data are
gathered in proper spatial units, their effects on
diseases could be studied much better.

- Specially, for the case of environmental pollutions, it
seems necessary to develop proper warning systems,
which are easily accessible and understandable by
public. The environmental protection organization
has developed such a warning and informing system
for the air quality of Tehran, which is daily used by
both organizations and public.

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