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The Role of GIS in The Management of Primary Health Care Services

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ABSTRACT

The application of Geographic Information Systems with health has been relatively slow to develop in Australia. The aim of this paper is to show the role that a GIS can play in the management of Divisions of General Practice (GP). We are proposing to use GIS to allow data in General Practice to be analysed visually through desktop mapping as a way of developing a Practice profile.

Most of the research projects in this area in western countries are at this stage of development. The favourable conditions in Victoria, Australia (due to the amount of complete digital data bases) allow us to be more ambitious. Thus the aim of the project presented through this paper is not only to reach a visual representation of the spatial health data but to explore the potential of GIS in the following issues:

- the combination of health data with other data such as the location and characteristics of private services related with health,
- spatial and thematic queries,
- sophisticated spatial analyses related with the optimal distribution and location of the practitioners,
- simulations regarding the actual and future demand, and
- optimal routing

Two Divisions of General Practice, one in rural Victoria and one in the metropolitan area of Melbourne, are being used in a pilot study. The data and results presented in this paper are related to these settings.

INTRODUCTION

The application of Geographic Information Systems with health has been relatively slow to develop in Australia. The aim of this paper is to show the role that a GIS can play in the management of Divisions of General Practice and to show the achievements and emerging issues related with the research project "GIS for General Practice".

The paper is composed of five main points. It starts giving a brief overview about the current state of GIS applications in the health sector in Australia. Secondly, we present the main objectives of the project "GIS for General Practice". In order to locate the spatial area of application of the project, a presentation of the Divisions of General Practice is given. We will present the early achievements of the project, including relevant preliminary findings and emerging issues. Finally, we will conclude with an overview of the future lines of research in this project.

HEALTH AND GIS IN AUSTRALIA

The health sector is a relative late comer to GIS technology, as many here will know. Whilst in other fields of applications where GIS is fully adopted by public and private agencies, health applications remain in a research stage prior to its integration.

The antecedents of the use of GIS in the health sector are in Health Geography where epidemiological studies seek a visual representation of medical data, particularly morbidity and treatment records. Health atlases are an example of this early approach of the use of mapping techniques in health applications.

The publications related with this field are focused either in epidemiological studies or in health services planning, most commonly for large geographic areas such as regions, or even countries. Applications of GIS at a local level are less commonly found. This can probably be attributed to problems related with the availability of data and the preservation of confidentiality, as we will comment later.

Some countries, such as the United Kingdom excel in the early adoption of GIS in health applications. Based on the National Health System, about 80% of general practitioners routinely collect computerised information on the health and treatment of their patients (Jones, 1997). This information, once submitted to health authorities, is used as part of their annual reports (Stevenson et al., 1996) and may be used to focus discussions between the health authority and local general practitioners about the development of primary care services. However, even in these countries were GIS has a longer tradition in the health sector, there are some problems that restrain a full application of GIS. In the case of the U.K., the lack of a well standardised collection and coding processes of GP records (Stevenson et al., 1996) make its use difficult in a GIS context, as aggregations and comparisons are often impossible. At the same time, the different administrative boundaries used by demographic and health agencies demands research in methods for linking health and population data (Walls et al., 1996), as is the case in Australia.

In the United States, as in other countries, the first studies on health and GIS were focussed on epidemiology applications. Due to its long tradition, the most outstanding studies are related with disease incidence rates, in particular use with disease registries such as cancer registries (Pickle et al., 1987). Apart from this classic approach, there are innovative studies about spatial accessibility to health services (Walsh et al., 1995) using GIS, and about the future directions that epidemiological studies should follow based on GIS technology (Clarke at al., 1996).

An exhaustive reference list related with GIS in health applications can be found in the article by Rushton and Armstrong (1997).

In the Australian context, uses of GIS in health to date generally address the issue of the provision of public health sector services. The South Australian Health Commission's Social

Health Atlas is one initiative which provides an overview of the health status and patterns of use of health welfare services of populations in different areas of the state (Glover, et al., 1996).

More directly related with GIS in health, Hennicke (1994) shows the process for implementing a GIS for health purposes. In the field of planning of emergency health services, a paper presented at AURISA in 1993 articulated different procedures used for emergency department catchments (Hennicke, Ezigbalike, and Bishop, 1993). There is also the case of the project "The Development of a Health Geodemographic GIS for the Department of Human Services - Hume Region" (1997) in which the National Key Centre for Social Applications of GIS (The University of Adelaide) explored the capacity of GIS in the study of locational disadvantages and epidemiology (Rudd and Nicolson, 1997).

Other relevant GIS and health projects held in Australia are related with the research of GIS functionality for the analysis and display of hospital data, specifically the Victorian Inpatient Minimum Dataset (VIMD) (Jackson et al., 1997).

The product HealthWIZ which is the National Social Health Database developed for the Australian Commonwealth Department of Health and Family Services, is another example which contains a wide range of local area health data and population data from all states of Australia, and which will integrate a mapping module into its data analysis features (Preston, 1997).

GIS FOR GENERAL PRACTICE PROJECT

The "GIS for General Practice" project is developing a Geographic Information System for Divisions of General Practice. This research project began in March 1997, after funding was made available by the General Practice Unit, Victorian Department of Human Services, in recognition of its commitment to information technology in the health sector. Within the 12-15 month research period, the aim is to develop a methodology for a prototype GIS to be used in this health setting. It is believed that improving information infrastructure will increase the divisions' understanding of the health needs and health status of their population groups, and will assist in informing divisional planning, education and research. In addition, it aims to be a complementary information tool for their evolving requirements in health outcome monitoring.

The Research Team for this project consists of the Department of Geomatics, University of Melbourne, the Centre for Community Child Health & Ambulatory Paediatrics (University of Melbourne) Royal Children's Hospital, and the National Key Centre for Social Applications of GIS, University of Adelaide. The two pilot divisions of general practice are North West Melbourne Division, an inner urban division with approximately 300 general practitioners, and East Gippsland division, a rural division in far eastern Victoria, with approximately 80 GPs.

DIVISIONS OF GENERAL PRACTICE

In order to provide some background, Divisions of General Practice is a relatively new organisational structure in Australia. It was designed to enable general practitioners to work together, and within the wider health care system, to improve the quality and continuity of care, to meet local health needs and to promote preventive care. The Australian Commonwealth Divisions and Grants Program provides corporate infrastructure for GPs to become involved in cooperative activities and projects to improve integration with other elements of the health care system. There are currently approximately 118 divisions in Australia, with a median population of about 153,000 per division (Commonwealth Department of Health & Family Services, 'General Practice in Australia: 1996').

Divisions are increasingly being perceived as an organisational vehicle to improve the health of the Australian population. It is currently feasible that these Divisions may be funded according to the success that they achieve in doing this. Data and information are therefore vital to this monitoring and funding system. In this context, the project "Geographic Information systems for

General Practice" seeks to explore the way in which GIS, could be used to better understand the dynamic health needs of an area-based population, such as that serviced by a Division.

PROJECT TO DATE

As a result of the large variety of data sets required in health applications of GIS, the project has concentrated, thus far, on data collection and data integration.

The initial part of the project was to establish the information needs of the two pilot Divisions. In order to meet their planning needs, data has been requested from sources at every available level: from federal, state, regional and local databases. Much of these data are routinely collected, and are relatively accessible. As we have mentioned before, the biggest gap in the availability of data is at the local level, and our project has begun to redress this, firstly by way of a questionnaire to all general practices in the catchment areas.

Figure 1 shows the model adopted for the implementation of a GIS, including the geospatial data and the attribute tables needed for this project.

The geospatial data includes:

Location of health services such as general practices, chemists, hospitals, etc.

Address data sets for address geocoding purposes

Road network

Administrative boundaries

The attribute tables include:

Questionnaires sent to general practitioners

Victorian Impatient Minimum Data Set (VIMD)

Community Services

Others

The difficulties of integrating geospatial data sets with different boundaries became evident early on. Figure 1 shows the incompatibility between population related data and boundaries used in the health sector. The implications of this incompatibility make it difficult to map an accurate profile of population living in Divisions of General Practice.

In addition to the questionnaire, original data collection for this project is concentrated in geocoding allied health services, for example chemists and alternative health practitioners such as acupuncturists and others.

Next, we present examples of some of the analytical possibilities that these data sets offer, once integrated into the GIS, and also the emerging issues that should be solved prior to the adoption of the GIS by the divisions.

Fig.1 Data sets to be included in a GIS designed for the health sector

Preliminary findings

The data sets integrated into the system (Census data, administrative boundaries, address layers, and georreferenced lists of addresses such as chemists and questionnaires to GP's) allow us to reach a wide range of GIS operations. Simultaneously, they demonstrate the problems that have to be solved in order to develop a useful GIS for the health sector.

The final utility of the implemented GIS would be to provide a powerful tool specifically designed for giving answer to a large range of geospatial problems that health agencies face in every day planning activities. Here are some examples of the potential of using GIS.

Mapping display

Many significant issues in health can be better understood through visual representation. Figure 2 shows, as an example, how GIS can be used for visual representation of a demographic profile.

In the particular case of the North West Division of General Practice, this figure shows how income is much lower in this area of Melbourne compared with the Victorian average. It is well known that income status has a direct relation to health status, accessibility and utilisation of health services. These kind of queries are commonly used by health planners.

Comparing this figure with figure 3, note that the original shape of the division is absent. This is due to the specific boundaries adopted by Australian Bureau of Statistics (ABS) - namely Collection Districts and Statistical Local Areas (SLA) -, presenting a very different size. This has the added problem of not matching with other widely used administrative boundaries, such as postcodes.

As boundaries of Divisions of General Practice are based on postcodes, and demographic data provided by the ABS is not attached to these boundaries, one of the first problems we found was the integration of different data sets. After presenting other examples related to spatial and thematic queries and allocation analysis, we will return to this problem.

Fig. 2 Demographic profile of population living in the North West Division of General Practice

Spatial and thematic queries

Responding to queries is one of the most common functions on GIS. In the GIS context, queries can be done in one or two manners; by paying attention to the spatial relations between elements, or by considering the attributes. Health agencies' needs are related to both.

Figure 3 shows the result of a simple kind of thematic query. The system was asked to show the size, in terms of effective full time medical staff, of the practices responding to the GIS questionnaire. The answer to this query could be either in an alphanumeric form, thus, showing the variable where this information is stored in the system, or it could be in the form of a map, as it is shown here.

Other possibilities, related with this GIS function, would be to ask the system about any of the other characteristics taken from the questionnaire and included in the data base, such as practitioners who store computerised records of patients, who offer services other than general practice, the average number of patients seen by month, or the number of GPs by postcode.

Fig. 3 GIS response for a size related query. GPs size.

Spatial analysis

The implemented system is consistent enough to perform different kinds of spatial analyses. A classical task of health services planners is related to the location and distribution of health services.

Figure 4 shows the important areas of the North West Division of General Practice that are not included in the areas served by the GPs. In this case we have used, as a spatial limit of influence of each GP, the average of the responses given by practitioners, to the question 'what do you estimate the maximum travel time to be, that any patient travels to see doctor/s at your practice?' Any other kind of limit, established by users, doctors or health agencies, could have been used. We adopted this one just to show one of the possibilities of network analyses using health data, but the implemented system allows us to perform similar kind of allocation analyses using, for example, health related services such as chemists, alternative medicine services or others.

North West Melbourne Division of General Practice. Allocated areas to Gp's. Distance limit: 3,500 m.

Fig. 4 Allocated areas to GPs. North West Melbourne Division of General Practice.

Emerging issues

The process we have explained, of implementing a GIS for the health sector, has demonstrated that the relevant issues are not concerned with analysis per se. The nature and amount of analyses to be performed are only limited by our imagination. As long as the system can contain the needed data sets, the analytical tools included in the GIS can provide solutions to health planning and some epidemiological studies. Nevertheless, there are a number of issues that should be solved prior to a complete integration of GIS techniques within the health sector. These issues are the following:

> Complexity of collecting health data for GIS at the local level. The project has identified issues that are particular to the smallest level of the geospatial hierarchy. Amongst them, morbidity and treatment data collection are the most relevant, especially for the purposes of epidemiological research. Initially, it was the intention of the project to collect data on trends of illness and treatment from general medical practitioners. However, the sample sizes within the scope of this project would not be adequate enough to make generalisations about the Divisions as a whole. Until more widespread data is collected and available from individual practices, the full potential GIS at this level is restricted.
>
> Confidentiality. The conventional method of preserving confidentiality of health records aggregates all records within a geographical area to a population large enough ensure to disclosure is prevented. Whilst this protects the privacy of the individual, it does restrict types of research and investigation of many important health problems.
>
> There are some alternative techniques that are currently being written up in the literature which are beginning to address confidentiality as it is applied to GIS (Armstrong et al., in press) but we still do not know if health agencies will concur with these techniques, which are based simply on moving, randomly, the location of patients to a different position.

Integration. Figure 1 shows the incompatibility between population related data and boundaries used in the health sector (Glover and Hugo, 1995). The implications of this problem make it difficult to map an accurate demographic profile of population living within the Divisions of General Practice.

In conclusion, we will outline some possible solutions:

The main problem found in health applications of GIS at a local level is the lack of availability of routinely collected data sets. As mentioned earlier, in the context of the NHS in the United Kingdom, a large proportion of practitioners routinely collect computerised records from patients. While in Victoria the situation is far from this (less than 25% of practitioners in our sample use computers in some way in their practice, mostly to prescribe pharmaceuticals), health studies at a local level will still be attached to surveys that are often very expensive, time consuming and, unfortunately, not generalisable. Even if this presents multiple inconveniences, we can be optimistic, as the trends for the future seem to be changing, and more and more practitioners are adopting the use of computers and digital data bases for managing their businesses. According to 'Victoria's Geospatial Information Strategic Plan: Building the Foundations', in a few years the majority of workforce will be computer literate and this scenario will certainly facilitate the use of computers in general practice.

Regarding the integration of data sets, a possible solution will be the design of a new system in the whole State, seeking the homogenisation of every kind of official spatial boundary. This solution is out of our control but it would be the ideal one. Other solutions adopted in this project are based on interpolation techniques that allow us to estimate the amount of people living in areas with boundaries other than those used by the ABS.

Privacy: The ideal solution to this problem is to preserve confidentiality but also to provide accurate information. The aggregation of data, either in points or in areas, seems to be a good solution for large areas studies. In the case of local studies, this solution restrains a good interpretation of the variability of data across the space. The adoption of random perturbation techniques (Armstrong et al., in press) seems more efficient and realistic.

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