ENABLING GEOGRAPHIC INFORMATION SYSTEMS FOR THE PUBLIC HEALTH SECTOR. A PROPOSAL FOR THE RESEARCH AGENDA

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1. Introduction

The health sector has been recognised internationally as one area of the potential new applications of geographic technologies[1]. Several groups in Australia and world-wide have been working with the application of geospatial information and Geographic Information Systems to aspects of health[2-4].

Since new applications need to address and solve issues that have not necessarily been considered or were not relevant to other applications with a longer tradition in GIS, this research agenda contributes to a more global research agenda on GIS.

This paper details the outcomes of the 'Research Agenda for Geographic Information Systems and Health' project carried out at The University of Melbourne, Australia.

In describing the project of a research agenda, this paper provides a summary of the major issues in need of discussion and research in the application of GIS to the Australian health sector to date, as perceived by the major stakeholders. The authors consider the issues most able to contribute to strengthening the future use of geospatial information in health service planning and service delivery.

The body of what has been identified as important to a future research agenda has emerged from a consultative process. In particular, this includes the Second Symposium on GIS and Health, 'Developments in the Application of Geographic Information Systems within the Health Sector'[5]; and a workshop on 'GIS in Public Health Research' held in June 1998. Both forum were attended by key public health, research, industry, government and education professionals from interstate and overseas, known to be interested and involved in projects of a GIS and health nature.

1.1 Background to the application of Geographic Information Systems

GIS is increasingly being recognised as having the potential to improve population health[6] and contribute to policy development, implementation, and research in public health[7]. Indeed, the World Health Organisation has noted that:

Geographical information systems are of value in the compilation and presentation of data at national and Region-wide levels, particularly environmental data and health outcome data related to the impact and use of health services[8].

Initially used in sectors such as natural resources, land management and more recently marketing and others, a GIS is an organised system of hardware, software, geographic data and people that is designed to efficiently capture, store, update, analyse and display all forms of geographically referenced information[9]. The two types of information in a GIS are spatial information, which

describes the location and size of geographic features [as well as topological relationships], and descriptive information, which characterises the geographic feature itself[10]. User-friendly windows-based software and Pentium computer technology have more recently made GIS tools much more accessible that it used to be in the past.

The application of GIS in health research is occurring world-wide in many areas: modelling the location of new services, children's health, injury, cancer, environmental health, just to name a few. GIS has begun to be used across the Australian health sector to study equity in the provision of services for the elderly[11], socio-demographic distribution[12] and service characteristics and service usage[13,14]. Whilst able to benefit to some degree from overseas research, these benefits are unable to be fully realised here due to a number of factors unique to Australia[15] and limited Australian experience, highlighting the need for locally-based research yet simultaneously building and maintaining international links.

Australian governments are increasingly recognising the need to improve spatial information and the services that relate to this kind of information with the introduction of policies for information technology uptake.

In the State of Victoria, for example an increasing amount of government data is being made available on-line through Land Channel[16], Better Health Channel[17] and Business Channel[18].

The use of geospatial information in the health sector is still evolving albeit in an uncoordinated way, and the mechanisms of delivering information continue to be re-defined[19].

1.2. Research agenda objectives

Identification of three basic circumstances gave rise to the development of a research agenda for GIS in the health sector. These are:

- The recognition of GIS as a valuable tool for policy making, implementation and research in public health,
- The emergence of GIS in the health sector in an uncoordinated way, giving rise to the need for greater communication and co-ordination; and
- Institutional, legal and technical issues related to early stages development are still unsolved.

The central goal of this research project was to harness international and national expertise in the under-researched fields of geospatial health analysis in order to develop a research strategy for area-based health analysis. Specifically the objectives were:

i. To evaluate and review international research themes and directions, where outcomes and processes have relevance and potential for further development in Australia, appropriate to the health of populations.
ii. To bring together the state-of-the-art knowledge and expertise of researchers working with population demographics, GIS, and health data by way of national and international collaboration.
iii. To establish mechanisms for on-going national and international linkages for the enhancement of research into this field.

The potential benefits to be gained from a GIS research agenda for the health sector have been identified throughout this project as:

- Reduction in costly duplication of research issues,
- Greater co-ordination and improved links between research, education, policy and service delivery,
- Improvement of health sector understanding of the use of geospatial information and of the benefits to public health of its use, where there is currently little or no understanding; and
- Linkage of organisations with complementary strengths to provide more comprehensive interchange and research opportunities and to strengthen the performance of one another's roles.

2. The Agenda

The need for research to be guided by specific issues emerged during this project. Rather than being exhaustive, the issues that follow are illustrative of current deficiencies or unexplored aspects of GIS in health in Australia. The most significant deficits in the current research cover a broad range and emanate from both the health and geospatial sectors. Collectively, they highlight the need for the flow of information between state and commonwealth governments, centres of research, and practice based participants where relevant.

2.1 Confidentiality

Today we assist world-wide to a conflict which origins reside on the society's demand for more and more accurate information and the individuals' rights to preserve their privacy. The vast majority of health-related databases have grown from information collected from individuals and groups. The

importance of maintaining people's privacy in the use of these data cannot be underestimated and it is generally well-accepted that the intention should be to ensure the minimisation of any potential harm to people. Traditional techniques of preserving confidentiality, such as aggregation of data, are useful, especially where the data are constituted in discreet, spatial units. Point-based health data are considered superior to area health data however, for its ability to be geocoded[2]. This raises the use of individual point data in Australia, an issue yet to be resolved. Although more recent techniques of masking individual data such as random perturbation, have been explored overseas[20], they have not been attempted in Australian conditions. There is scope for the trial of these methods, in consultation with consumer representatives and data custodians.

2.2 Data integration

GIS allows data from a range of different sources to be integrated in a unique system. When these data have their origins in diverse environments, several difficulties are likely to emerge. Differences in data collection routines, data standards, data formats and spatial scales could make the integration process a difficult task, as many of the 1998 Symposium participants confirmed.

The authors are particularly concerned with the problem of incompatible spatial units. As a consequence, methods are beginning to be investigated that can homogenise the various administrative boundaries to which health data are attached. These boundaries are, in most countries, non-coterminous, which make the application of cross-analysis techniques difficult.

It is recognised that a lack of hierarchically organised boundaries restrains the use of GIS[21]. Recognition of the need to develop and promulgate "a set of national geographical boundaries, identifiers and aggregations for use in all population-based health data collections and surveys and a mechanism for coding current historical address information to this classification" has been acknowledged in the Australia's National Public Health Information Development Plan (NPHP)[22]. The development of a new model of administrative boundaries based on Spatial Hierarchical Reasoning[23] will contribute to the integration of the data sets to which each agency is custodian.

The concept of a spatial hierarchy was debated during the course of this research. Spatial hierarchy is one of the most common forms of organising and structuring complex systems. In the past, high priority has been given to research on Spatial Information Theory that investigates the conceptual hierarchy of space and spatial phenomena. It is an issue that has been articulated by all users of GIS, not only in the health sector. The spatial hierarchy issue is being examined by the Geospatial

Information Reference Group (GIRG)[24], convened by the Victorian state government, to advise on issues related to the development and use of geospatial information. Research initiatives to address spatial hierarchy include work done by Eagleson et al.[25].

2.3 Metadata

The number of databases relevant to the public health of populations and individuals are multitudinous. The Victorian government is attempting to establish common metadata (data about data) for all departments and databases in recognition of the large amounts of good quality data in Victoria. This will permit better access to useful descriptions of what are available. The implementation of engines, standards and visual display for metadata is currently undertaken by a significant number of research projects world-wide[26].

2.4 Access to data

After two decades of exhaustive use of GIS, there are still many unsolved issues about access to data. The first question is "does data exist?" The answer to this question is more often in the affirmative, giving rise to additional questions:

- "Who are the custodians?",
- "What is the price?",
- "It is there any pricing policy?",
- "What are the channels for access to data such as the Internet?"

Research is needed to examine how government information policies affect the access to, and use of, data by a broad spectrum of public and private sector stakeholders for a variety of public and private purposes.

2.5 Data quality

Quality data is essential in a GIS for a number of reasons. It allows for the interchange of data, it ensures credibility of the data, it maximises efficiency by permitting faster system development and it improves decision making by the information users. Many data are not routinely collected, or are collected in a random, unsystematic way. This leads to various forms of errors including positional errors, attribute errors, logical consistency and completeness[27]. Extensive differences in data collection techniques, both within the health sector and cross-sectorally, currently create enormous difficulties for integration of data in a common system for GIS. As an example, one of the biggest gaps in health data is morbidity and treatment data by geographic location, specifically at individual

practice level which, in a GIS environment, could be represented as point data. The application of GIS in the health sector requires a revision of the way that data are collected, used and displayed. Procedures to collect, deliver and summarise data have been identified as being in need of further work.

Ensuring that the data within a GIS are current is an important issue in all GIS-related projects. In order for an implemented GIS to be of value, regular updating is required. Mechanisms to customise the collection and integration of new data into an information system are under research[28]. For the health sector, however, where GIS has only recently been introduced, methods of regularly updating health data sets are in need of exploration.

2.6 Use of qualitative data

Consideration needs to be given to ways in which qualitative health data, that include lay perceptions of health and illness and the 'lived' or socially experienced dimension of health[29], can begin to be incorporated into a GIS framework. Both the National Center for Geographic Information and Analysis (NCGIA) and the University Consortium for Geographic Information Science (UCGIS) have highlighted the issue of cognitive information and reasoning within GIS. Aspects such as personal preferences, perception of services and cognitive distances, have not yet been incorporated successfully in a GIS environment but are important for adequate planning policies.

The UCGIS has been working intensively on the issue of cognition for many years. The UCGIS stated that ‘it has become clear that an understanding of certain aspects of human cognition is essential if future geographic information technologies are to realise their full potential as tools in the service of human decision making”[30].

2.7 Organisational support

One of the components of a GIS is people, however little work has been carried out on what new users of GIS require in relation to education, training and on-going support. Organisations and individuals in the health sector for whom GIS is a new tool should be of particular interest. One evaluation research project examining the introduction of a GIS in a primary health setting of general practice has found that the issues of organisational framework and technology transfer require careful consideration[31]. Preparation and on-going support of staff appear to substantially influence the use of the GIS present[32] though follow-up work is needed to investigate more widespread adoption of information technologies such as GIS.

If the health sector is to take up the use of geospatial information on a broader scale, it would be advantageous for planning and budgeting purposes to have a sound knowledge of (a) the support that organisations need to provide; and (b) what recipient organisations may need in an on-going capacity.

2.8 Education in GIS and Health

In order to advance GIS in the public health sector, consideration needs to be given to the integration of the instruction of GIS into curricula of public health schools through geography programs, geomatics and computer science courses. A worthy body of GIS education already exists within Australia and overseas that could be adapted to a new set of demands. A range of initiatives to incorporate GIS in secondary school curricula is underway in the United States. Education could be promoted through formal and informal learning opportunities, part-time options, distance learning and workshops and needs to include basic information technology and health geography[10].

2.9 Partnerships

Strategic alliances are necessary when bringing a new technology into a new sector.

Whilst the problem of connectivity related to developing and managing multi-sectoral research has been identified by Australia's National Public Health Partnership[22], this has not been the experience of many of those who are working across the health and geospatial sectors.

Real outcomes have emerged from those projects in GIS and health that have used cross-sectoral and intra-sectoral partnerships within Australian and overseas. The concept of partnership also applies to the different agencies that deal with health services and GIS respectively. Links between local, state and national government jurisdictions have been established, yet this communication needs to be modelled and co-ordinated in a way that maximises these associations and harnesses the potential for work to continue between partners.

The importance of a high level of communication and co-operation between the health and non-health sector, has been acknowledged in the National Public Health Information Development Plan[22] and endorsed by the Australian Health Ministers' Advisory Council.

The problem of fragmentation, also identified by the NPHP as a barrier to public health research and development[22] and largely due to geographic and jurisdictional reasons, has emerged during the consultation phase of this project. Valuable and valued links have been developed across the two sectors in question, with geography not necessarily a perceived barrier. However, there was

consensus that agencies need some support to prevent communication from becoming *ad hoc* and to enhance information sharing in an Australian context given that there is no one body or infrastructure to take a leadership role and represent these issues. This could take place either by way of regular cross-sectoral forum and/or electronic discussion groups for those who work in a common area albeit in different settings.

2.10 Time and GIS / Time in health data / Space-time relationship

Temporal data are crucial to understanding health issues. However, GIS as a tool to manage geospatial information is still has problems in analysing and managing temporal data.

The NCGIA has listed this issue in its Research Initiative 10: Spatio-Temporal.

"The objectives of this initiative are to:

- Study spatial applications to identify properties of different time concepts such as continuous, discrete, monotonic, and cyclic;
- Explore alternative mathematical formalisations to Cartesian co-ordinates and Euclidean geometry, which represent spatial and temporal reasoning processes better;
- Formalise human reasoning processes about geographic space and time;
- Build computational frameworks, within which geographic phenomena and processes, and their temporal changes can be simulated;
- Examine computational reasoning methods with observations from human subject experiments about human spatial and temporal perception and cognition"[33].

In this context, at GEOMED'99, Professor David Mark presented a research project that is "developing and testing tools and procedures for spatio-temporal analysis of environmental health data in a GIS framework"[34].

2.12 Distributed computing

As the UCGIS states, "digital technology is moving rapidly to distributed computing. It is now possible for parts of a database to be stored and maintained at different locations; for users to take advantage of economical or specialized processing at remote sites; for decision makers in collaborate across computer networks to making decisions; or for large archives to offer access to their data to anyone connected to the Internet"[30].

To be able to integrate datasets from different agencies, custom interfaces are needed to communicate between software across multiple operating systems, networks and architectures[37].

These new possibilities and issues are currently under research by sectors related to librarians, cadastral information experts, and geographers to name a few but they have not yet been fully explored in the health sector.

2.13 Facilitating research transfer

The practice of disseminating research results is becoming more widely integrated into responsible research practice in the health sector and is frequently now a consideration at the project development stage[38]. Results of research, both successful and unsuccessful, that emanate from health and geospatial research need to be disseminated to the community who has participated in the research and to the community for whom the research is intended. Improved cross sectoral channels of communication would facilitate the transfer of research results by widening the audience beyond individual professional groups and beyond even multidisciplinary groups within each sector. This would permit opportunities for discussion on the action needed on research results and implications of the research, both of which could assist in reducing the gap between research and practice and between different jurisdictions.

3. Conclusion

GIS has already been shown as a useful tool for data storage, analysis and presentation in other sectors. Demands for data and ways of managing data are growing rapidly in Australia. More widespread interest in the potential of GIS in the health sector has emerged in recent years, for its ability to meet immediate, operational needs and to assist in decision support.

This report summarises the gaps in knowledge and skills identified by those interest groups at the intersection of the health and geospatial sectors, currently an area of under-developed research. It attempts to identify the action that is needed to improve the application of GIS to the health sector, with the ultimate enhancement of planning, service delivery and evaluation of programs. The issues most able to contribute to strengthening the future use og geospatial information in health service planning and service delivery have been considered.

A number of the aforementioned mechanisms are required in order for the potential of GIS to be attained in the health sector. These may be overcome, at least in part, by improved co-ordination, communication and multidisciplinary collaboration. Existing processes can contribute to the

realisation of these research issues, however additional resources will be required to initiate on-going research in a more sustained and widespread capacity.

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