

South Island Rural Unit Needs Assessment System (RUNAS) – Stage 1: The Development of a Healthcare Spatial Analysis System

Pat Farry, George Benwell, Kit Macgillivray, Kaine Elston, Martin Williamson and Murray Tilyard

Te Waipounamu Rural Health Unit, Department of General Practice
and
Department of Information Science, Spatial Information Research Centre
University of Otago, Dunedin, New Zealand
Phone: +64 3 479-8301 Fax: +64 3 479-8311
Email: pfarry, gbenwell@otago.ac.nz

**Presented at SIRC 2000 – The 12th Annual Colloquium of the Spatial Information Research Centre
University of Otago, Dunedin, New Zealand
December 10-13th 2000**

ABSTRACT

This paper describes the establishment of an open ended spatial information system for the management, analysis and presentation of primary health care information for the rural areas of the South Island, New Zealand.

Keywords and phrases: rural health, health needs assessment, spatial analysis, primary health care

1.0 INTRODUCTION

Te Waipounamu, the rural health unit for the South Island of New Zealand was established by the University of Otago and South Link Health in August 1999 with a grant from the Health Funding Authority. The purposes of the unit are to:

- ensure there is equity of health care services of a high quality to all South Island residents outside of the large metropolitan areas.
- facilitate undergraduate and postgraduate education programmes in rural health.
- undertake appropriate research in rural health.

Acknowledging the paucity of spatially integrated information regarding general practitioners, practices and the population to which they provide care, the Te Waipounamu Rural Health Unit in conjunction with the Department of Information Science and Spatial Information Research Centre (SIRC) set about designing an analysis system. Given the particular concerns of rural healthcare and the need to integrate data from a variety of sources, a spatial information system (SIS) was proposed that would act as a baseline for the current rural primary healthcare situations. The system was to be a general tool for spatial and non-spatial analysis of the important issues surrounding the management of rural primary healthcare. Such issues include the supply of, and demand for services of both individual practices and South Island wide, needs assessment, policy development and assessment, health funding structures, spatial correlations between socio-economic statistics and incidence data and measuring and identifying remoteness and deprivation.

2.0 THE SYSTEM CONCEPT

A proof-of-concept GIS (Rural Unit Needs Assessment System: RUNAS – Stage 1) was developed as an outline for larger-scale implementation. This paper documents the development methodology, component information of RUNAS and the problems and considerations encountered during development.

The South Island Rural Unit Needs Assessment System was designed to build up a comprehensive spatial database of all the health care services available in the South Island, the populations, which would require these services and their actual utilisation. This project is particularly pertinent to the change to District Health Boards and their requirement to undertake health needs assessment.

3.0 BASIC INFORMATION CONTENTS

There are a number of layers of data covering health care delivery in New Zealand that need to be included.

3.1 The distribution and availability of rural health care services including:

- General practice services both doctors and nurses
- Emergency services including ambulance, first rescue and helicopter rescue
- Rural and provincial hospitals and the services provided by them
- Rural Maori health services
- Rural obstetric care services
- Pharmacies and laboratory services
- Physiotherapy and occupational therapy
- Rural mental health teams
- Visiting consultant services
- Mobile technologies eg, cardiac, mammography, surgical and retinal photography
- Rural community health trusts and companies
- Road systems

3.2 The rural health care requirements and priorities including

- New Zealand census data within meshblocks
- Maori demographics
- NZ deprivation index which is based on income level, communication systems available, home ownership, living space, qualifications and supports
- Hospital waiting lists for outpatient appointments and for inpatient admissions and surgical treatment

3.3 The utilisation of health services

- Patient primary care data from computerised general practices
- Disease registers in general practice
- Patient management by ambulance services
- Patients attending mental health services
- Patients receiving secondary and tertiary care through National Health indicator numbers
- Notifiable disease data
- Preventive management such as vaccination data, cervical screening, mammography.

The main objective of the first stage of RUNAS development was to provide baseline information regarding primary healthcare in rural South Island and to stimulate discussion about potential uses and value of further development. Baseline information was to address several gaps in current knowledge related to the location of primary healthcare services, information regarding practices and general practitioners and the relationships between socio-economic profile and geographic region. Such baseline information is expected to highlight potential research issues to be addressed during the next stage of RUNAS development.

4.0 POTENTIAL SYSTEM USERS

It is anticipated that RUNAS will provide important baseline data and information for rural health care providers, policy developers, community interest groups, professional, government, area health bodies and Te Waipounamu Rural Health Unit. Themes that are currently in development include:

- The identification of people who live greater than 30 minutes away from various health services and correlating this with age, socio-economic status, ethnicity and morbidity.
- The relationship between the distribution of services and morbidity e.g. the incidence of advanced breast cancer or distance to diabetic referral photography and the incidence of diabetic related loss of vision.
- The travel time for emergency services to reach any point on a rural road or farm
- The relationships between teenage pregnancies, distribution of sex education programmes and availability of family planning and abortion services.
- Patient profiles within each practice catchment e.g. the percentage of smokers, the deprivation index, percent Maori population, the incidence of certain diseases and the uptake of preventive measures.
- Ensure that we are at all times providing an environment into which data can be easily integrated
- Ensure awareness of ethical especially privacy issues.

5.0 SYSTEM DESIGN AND DEVELOPMENT

RUNAS was designed and developed following established methodologies for system development (Benwell 1994). Following this process, meetings were held with the Rural Health Unit to establish the main goals of Stage 1 (refer to Aims section above). Given the requirements of the system, it was decided that the commercial SIS package ArcView was suitable for initial system development. The use of ArcView allows for the integration of both spatially referenced and non-spatial data.

Within ArcView, spatial data layers were mapped as “themes” with each spatial layer having associated attribute (textual) data (Figure 1). For example, rural South Island medical practices were mapped as a spatial data layer with attribute data such as GP names, age, gender, etc. attached to each practice. Attribute data layers are stored within a database related to the associated spatial objects. Such an integration of data from a variety of sources allows for spatial and non-spatial querying and analysis of the baseline data (Figure 2).

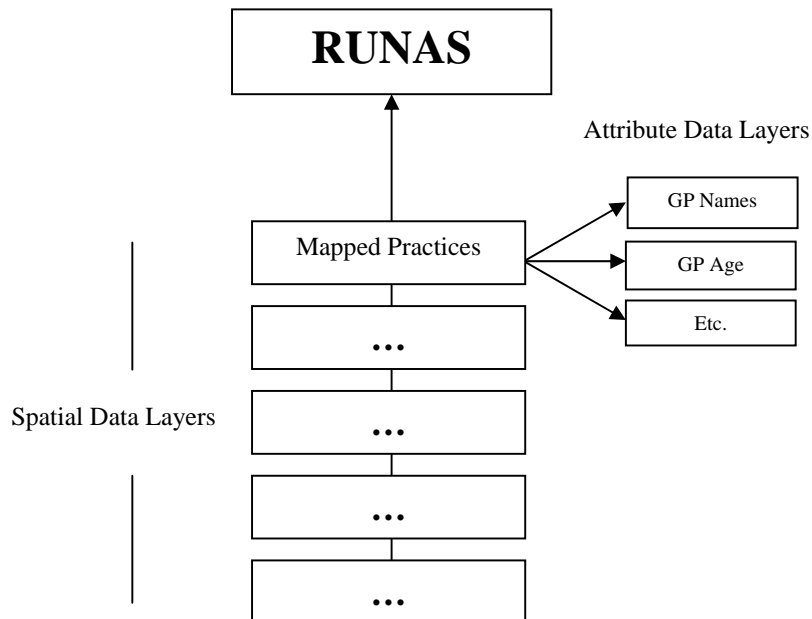


Figure 1 Schematic diagram of system design showing the conceptual relationships between spatial data layers and associated attribute (non-spatial) data.

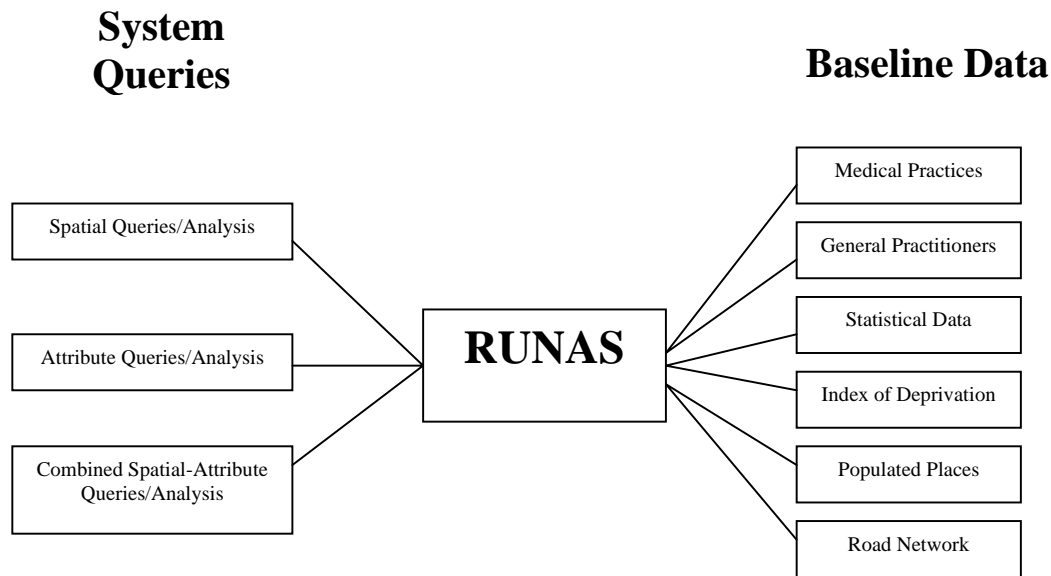


Figure 2 Schematic diagram of RUNAS querying and data layers

The main focus of stage 1 of RUNAS was data-driven; to collect and integrate required baseline data. To do so, spatial data and attribute data were collected from a variety of sources. Much of the data used for stage 1 of RUNAS was pre-existing data that was collated, mapped and integrated into ArcView themes. However, new data was also required and collected. The following sections specify the data layers used (both spatial and non-spatial), their sources, particular attributes and the methods used to create data layer themes for integration within ArcView. The relationships between all attribute and spatial data layers are shown in Figure 3.

6.0 EXISTING DATA LAYERS

6.1 Medical Practices

All rural South Island practice addresses were determined from the General Practice rural registrar. Each practice was then geocoded within ArcView and mapped.

6.2 Population Statistics

Socio-economic statistical data collected by Statistics New Zealand in Census 1996 were collated at the meshblock scale (population <200) for all rural areas of South Island (i.e. excluding Christchurch, Dunedin and Invercargill). Appendix A contains the categories of statistical information used for RUNAS. Census data supplied by Statistics New Zealand is intentionally perturbed for the purposes of privacy. Socio-economic statistics are only available across whole meshblocks and values are accurate to within 3 people. All statistical data as described in Appendix A were then attached as attribute data to the meshblock geographic boundaries obtained in polygon form from Statistics New Zealand enabling the mapping of census data.

6.3 Index of Deprivation

The index of deprivation scores meshblocks according to a variety of socio-economic criteria (Salmond *et al.* 1998) with a value of 1 being the least deprived and 10 being most deprived. Index scores were obtained from the Health Services Research Centre, Wellington, New Zealand and attached to mapped meshblocks.

6.4 South Island Road Network

All major roads in rural South Island were combined in ArcView from the digital New Zealand 1:50,000 Topographic Vector Data series as supplied by Land Information New Zealand (LINZ). See LINZ for information

concerning data collection, positional accuracy and attribute accuracy. The roads were then networked within ArcView using the Network Analyst extension.

6.5 Populated Places

All populated places in rural South Island were mapped as points. Positional data for each place was provided by the New Zealand Geographic Place Names Database, Land Information New Zealand's (LINZ) central repository for place names that appear on topographic maps of New Zealand. See LINZ for information concerning data collection, positional accuracy and attribute accuracy.

7.0 COLLECTED DATA

In addition to the integration of existing data, information was collected specifically for RUNAS. Data were collected by the Rural Unit using custom-built ArcView interfaces.

7.1 General Practitioner Information

Attribute data gathered regarding GPs included name, age, gender, educational background, workload and particular training and specialities. Data were input directly into RUNAS via a form page. GP data were created as a component of each mapped practice and was able to be queried as such.

Collected practice data were attached to mapped practices allowing for querying and analysis.

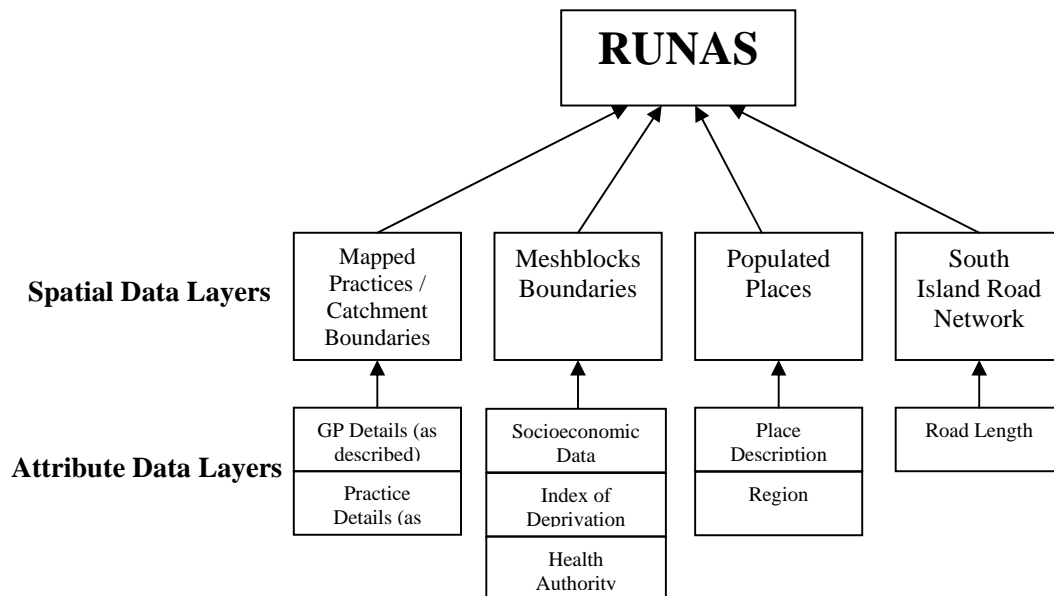


Figure 3 Data dictionary for RUNAS: data and data relationships between spatial and attribute data layers.

7.2 Practice Information

Practice attribute data were collected by querying the associated GPs and entered directly into RUNAS via a form page. Data were collected for:

- The number of full-time equivalent GPs
- Presence and number of nurse practitioners, midwives, patient educators, physiotherapists, speech therapists, occupational therapists, pharmacists and district nurses.
- Services provided by visiting consultants, i.e. surgery, psychiatry, paediatrics, oncology, dermatology, orthopaedics, ENT surgery, ophthalmology, plastic surgery, cardiology, respiratory, diabetology, geriatrics, obstetrics.
- Accessibility to mobile technologies, i.e. cardiology, mammography, retinal photography and lithotripsy.

7.3 Practice “catchment” Borders

Practice boundaries (“catchments”) referring to the geographic extent of a practice’s patient load, were estimated by the associated GPs. Boundaries were drawn as polygons directly into RUNAS using custom-built input tools. Mapped catchments were defined as components of the associated practices.

8.0 RUNAS OUTCOMES

With the collection and mapping of all baseline data, each theme was integrated as layers in ArcView. RUNAS could then be used for spatial and non-spatial querying and analysis of the baseline data. Examples of potential queries and analyses that RUNAS is capable of include:

- Determine and map all areas where people live greater than a certain distance from a primary healthcare provider (Figure 4).
- Determine the socio-economic profile of these people, i.e. age, income, ethnicity.
- Thematic mapping of South Island and within practice boundaries to highlight areas of deprivation and concern, i.e. high percentage of smokers.
- Determine population profiles within each practice’s service areas, i.e. percent smokers, percent Maori, average income, etc. (Figure 5, 6).
- Determine the nearest primary healthcare provider for any point on a rural road and travel cost/time to that provider.
- Examination of relationships between socio-economic data, deprivation and location.

Such querying and analytical abilities satisfy the main goals of RUNAS both in terms of providing baseline information about primary rural healthcare in South Island and as an exploratory tool of healthcare issues. The examination of health issues, both spatial and non-spatial with RUNAS is expected to stimulate and guide further research into particular areas. For example, RUNAS could be used to explore the relationship between access to mammography units (a spatial question) and socio-economic condition (a non-spatial question). Such analysis may prompt further research into this area such as examining these relationships with the addition of incidence data on breast cancer and mastectomies, i.e. is distance from a mammography unit correlated with number of mastectomies? The ideas and research questions raised by RUNAS are then expected to guide the future stages of RUNAS development.

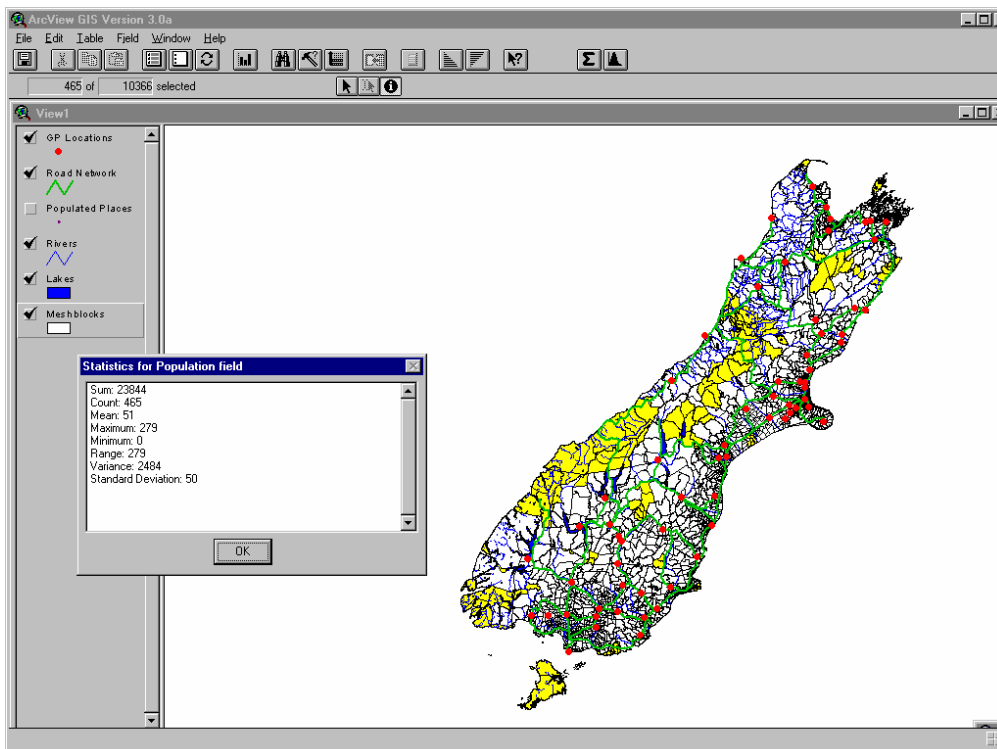


Figure 4 Screen shot from RUNAS after spatial distance query.

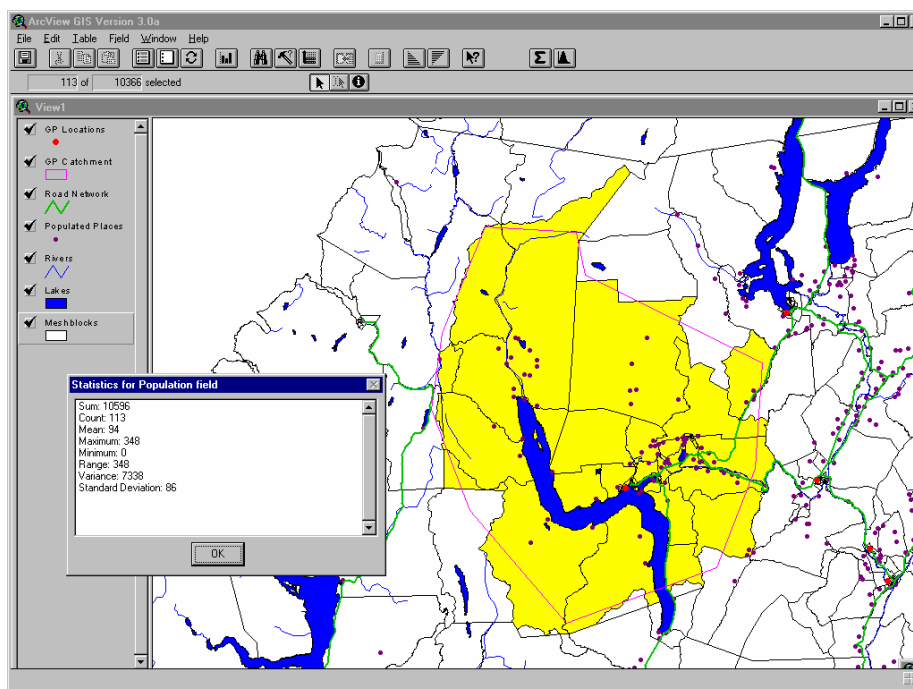


Figure 5 Screen shot from RUNAS of a population query within a practice boundary.

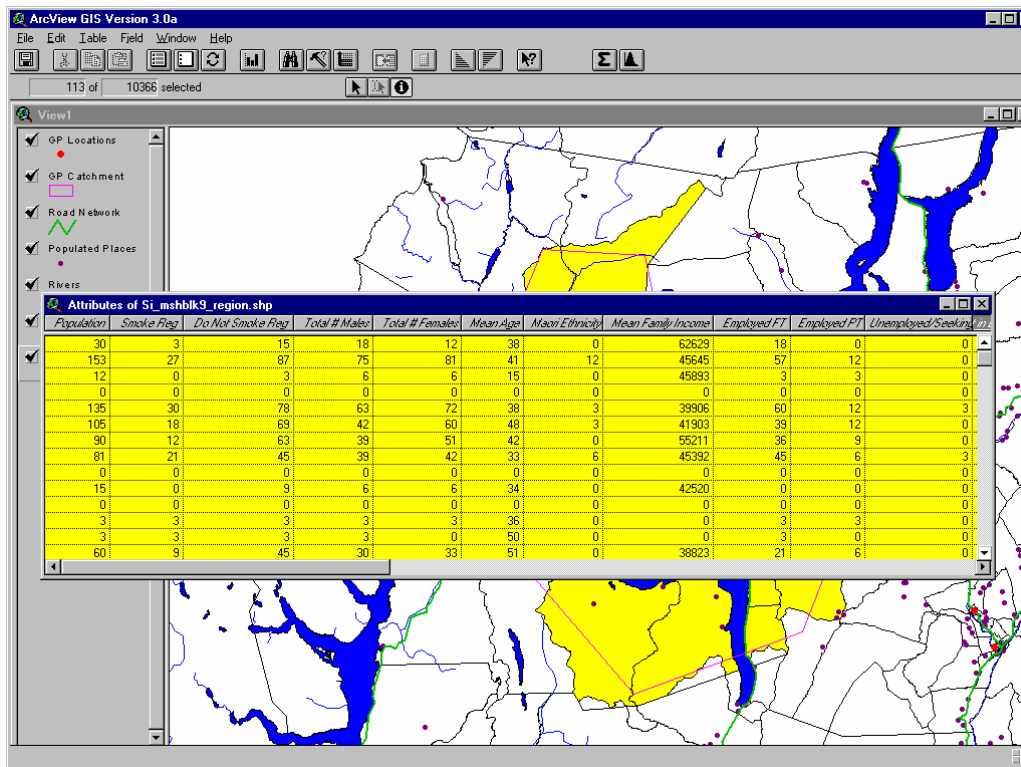


Figure 6 Screen shot from RUNAS of a population profile query within a practice boundary.

9.0 ISSUES AND CONSIDERATIONS

The development of RUNAS has highlighted several problematic issues. The primary problem encountered during development was the lack of a clear goal, that is, the end users had only a vague idea of their needs and requirements. Though this stage of development was data-driven, focused upon providing a baseline for the current primary healthcare situation, any future development must be orientated towards particular, well-defined problems and analyses. Related to this problem is the observation that end users often have difficulty seeing past “pretty maps” meaning that GIS systems are often aesthetically attractive and this can detract from more critical assessment of their uses and analytical abilities.

At a conceptual and technical level, RUNAS and other GIS systems that integrate different polygon zones face the “areal unit problem” (Goodchild *et al.* 1993). This analytical problem arises when the boundaries of two or more polygons do not line up. When analysing areas of overlap between the two or more polygons (for example a meshblock and a practice catchment), the interpolation of polygon attributes within that polygon is a difficult and error-prone process. Though several methods are available (e.g. Tobler 1979; Goodchild and Lam 1980; Lam 1983; Flowerdew and Green 1989), all require assumptions that are unlikely to be met. Future RUNAS analyses that encounter this problem must acknowledge these associated assumptions and errors.

One of the main objectives of RUNAS was to guide future stages of RUNAS development. Some important considerations for further RUNAS development as highlighted by Stage 1 include:

- RUNAS should have the ability to integrate other data sources, particularly incidence data from health databases and patient information from GP databases.

- An improvement in data collection methods. Currently, data collection for practice catchments is error-prone and only a rough estimate. It is suggested that a consistent methodology be used for future data collection, accounting for errors.
- More resources must be given to end-user training. Both end-users and developers must commit resources for proper training, particularly in RUNAS analysis.
- The ethical issues surrounding access and analysis of healthcare data in RUNAS must be formalized.

These problems encountered and considerations should help guide future development stages of RUNAS. It is considered important that any end-user analyses using RUNAS acknowledge the discussed problems and considerations.

10.0 CONCLUSIONS

Spatial information systems such as RUNAS allow for the integration of data collected from a variety of sources. By doing so, the first developmental stage of RUNAS provides a valuable system for the examination and analysis of baseline data of importance to primary rural healthcare issues. While providing baseline data, it is the exploration of this data that is expected to be of most value as RUNAS is used to stimulate and guide future research and development. Stage 1 has also highlighted several pitfalls and considerations to take into account for future research and system development. The integration of spatial and non-spatial data in a spatial information system has been shown to have much potential for the exploration and analysis of healthcare problems. While RUNAS is a considerable improvement upon the previous situation, it is necessary for the end-users to establish specific problems and areas of research upon which future stages of RUNAS development can be focused.

11.0 APPENDIX

Census 1996 statistical categories used in RUNAS.

- Number of people:
- Resident population
- Regular smokers
- Non-smokers
- Never smoked
- Smoked regularly
- Average family income
- Average age
- Number of males
- Number of females
- Maori ethnicity
- Households with children under 5 years old
- Households with more than 1 superannuitant
- ACC claimants
- National superannuation claimants
- Unemployment benefit claimants
- Domestic persons benefit claimants
- Sickness benefit claimants
- Invalid benefit claimants
- Student allowance claimants
- Other government benefit claimants
- Average family income
- Employed full-time
- Employed part-time
- Not in labour force
- Loss income
- Zero income
- Annual income of \$1-\$10000
- Annual income of \$10001-\$20000

Annual income of \$20001-\$30000
Annual income of \$30001-\$40000
Annual income of \$40001-\$50000
Annual income of \$50001-\$60000
Annual income of \$60001-\$70000
Annual income of \$70001-\$100000
Annual income of >\$100001
No accessible vehicle
1 accessible vehicle
2 accessible vehicles
3 or more accessible vehicles
Telephone accessible
Telephone inaccessible

12.0 REFERENCES

- Benwell, G.L. 1994. A system development methodology for geomatics as derived from informatics. *Department of Information Science Discussion Papers Series, No 94/6*, University of Otago, Dunedin, N.Z.
- Flowerdew, R. and Green, M. 1989. Statistical methods for inference between incompatible zonal systems. *In: Accuracy of Spatial Databases* (eds. M.F. Goodchild and S. Gopal), pp. 239-248. Taylor and Francis, London, U.K.
- Goodchild, M.F., Anselin, L. and Deichmann, U. 1993. A framework for the areal interpolation of socioeconomic data. *Environment and Planning A*, 25: 383-397.
- Goodchild, M.F. and Lam, N.S-N. 1980. Areal interpolation: a variant of the traditional spatial problem. *Geoprocessing*, 1: 297-312.
- Lam, N.S-N. 1983. Spatial interpolation methods: a review. *American Cartographer*, 10: 129-149.
- Salmond, C., Crampton, P. and Sutton, F. 1998. *NZDep96 Index of Deprivation, Research Report No 8*. Health Services Research Centre, Wellington, N.Z.
- Tobler, W.R. 1979. Smooth **pycnophylactic** interpolation for geographic regions. *Journal of the American Statistical Association*, 74: 519-530.