Measuring spatial accessibility to primary health care

Nasser Bagheri, George L. Benwell & Alec Holt

Department of Information Science
Phone: +64 3 479-7390 Fax: +64 3 479-8311
Email:{nbagheri}, {gbenwell}, {aholt}@infoscience.otago.ac.nz

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ABSTRACT

The aim of this paper is to explain a new approach for calculating spatial accessibility to primary health care (PHC) services. New Zealand and World Health Organisation (WHO) rules were used to determine acceptable levels of minimum travel time and distance to the closest PHC facilities via a road network. This analysis was applied to 2369 census areas in the 2001 census release with an average population of 76 people and 32 PHC services inside the Otago region. The best route (shortest time) from residential areas to PHC facilities was calculated using the mean centre of population distribution within each meshblock polygon instead of using simple geometric centroids of the Meshblocks. This study has shown that the central and northern parts of the Otago region have some areas with low accessibility levels to PHC.

***Keywords and phrases*:** Primary health care, accessibility, WHO rules, best route, network analysis

1.0 INTRODUCTION

Primary health care (PHC) is an imperative strategy to providing *"health for all"* and is widely acknowledged as a universal solution for improving population well-being in the world (World Health Organization and UNICEF 1978). PHC is crucial as it is a very cost-effective method of health care (more affordable and easier to deliver than specialty or inpatient care). Therefore if PHC is equitably distributed it can play important role in preventing diseases and decreasing health inequality on a large scale in society (Guagliardo 2004).

Access to PHC is one of the indexes to achieving the goal of *"health for all"* and it has different definitions depending upon different contexts. There are two major dimensions for access, 1) potential and 2) realized. Potential accessibility is seen when a disadvantaged residents live in place and time with an enthusiastic and capable health care delivery system. Realized or actual access, follows when all barriers and impediments to PHC are removed. Although the number and the type of barriers to accessibility of PHC differ from country to country and time to time, Penchansky and Thomas (Penchansky 1981) have categorised barriers into five types.

1. availability,
2. accessibility,
3. affordability,
4. acceptability,
5. accommodation.

The last three types (3, 4 and 5 above) are known as non spatial barriers and reveal socio-economic factors. The first two types (1 and 2 above) are generally spatial in nature. Availability in the context of PHC refers to the number of health care service points which needy people can choose. Accessibility is travel impedance (distance or time) between residential or demand areas and PHC services or destinations. In this research, availability and accessibility are considered as "spatial accessibility" and the aim is to determine, if Primary Health Care services are equitably distributed within a community/country based on World Health Organisation (WHO) rules and a country health policies. This paper explains the methodology and primary results of testing a new approach for measuring spatial accessibility to PHC within the study area.

Modelling accessibility applied to health care has been an area of on-going research. Hall & Bowerman(Hall and Bowerman 1996) have to date produced to most elegant approach with their *AccessPlan* software, which various WHO office currently use. This paper differs in that it is focusing on more precise data sets and techniques, for example, using road networks, sinuosity and exact population figures.

2.0 METHODOLOGY

2.1 Study area

In this research, we chose the Otago region (Figure 1), New Zealand, as the testing area(Bagheri, Benwell et al. 2005). The population and the area of Otago is 181542 and 3857.94 square km respectively (New Zealand Statistics 2005). According to the available data sets (2001), there are 32 PHC locations in the rural Otago area (Figure 2).

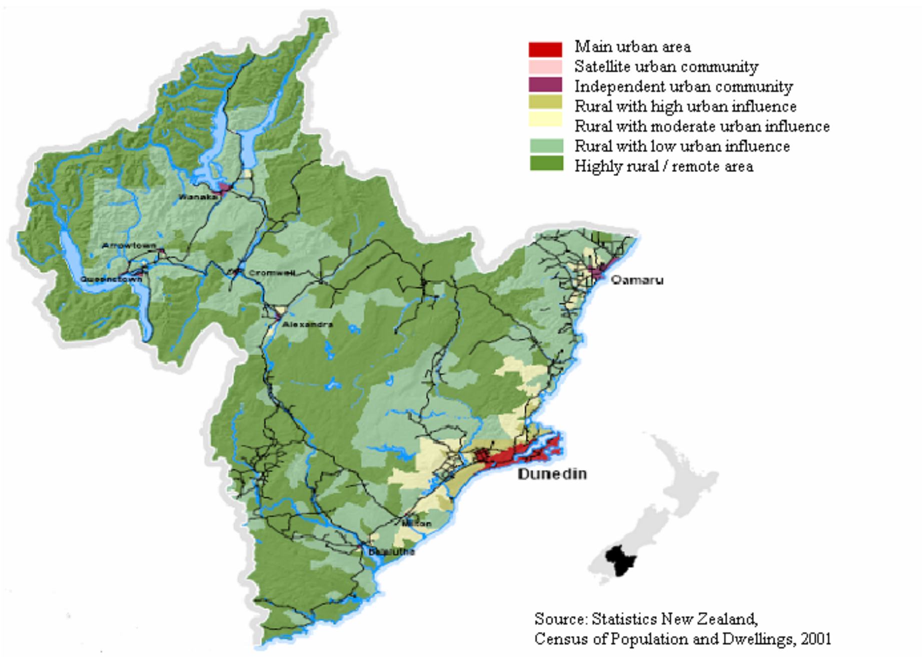

Figure1: Urban/Rural profile categorise: Otago region

2.2 WHO rules

In the context of accessibility of PHC, WHO's rule is universal access regardless of where the people live or work (World Health Organization and UNICEF 1978). However, there are some unofficial guidelines from the WHO, for example, one General practitioner for every 1000 people.

2.3 New Zealand health policy

The New Zealand Ministry of Health emphasises PHC services must be available for 95 percent of population in New Zealand during (New Zealand Ministry of Health 2001):

- normal business hours = within 30 minutes travel time and

- after hours = within 60 minutes travel time.

2.4 Data

New Zealand Census Meshblocks (2001) information and road network files used to calculate the minimum travel time (using road, road type, topography, traffic etc.) from residence areas inside of each meshblock to PHC locations. There are approximately 2369 census areas in the 2001 census release with an average population of 76 people.

2.5 Modelling travel time to the closest PHC services

In regard to spatial accessibility to PHC services, there have been a number of researches that have used straight-line distance (Euclidean distance) and thiessen polygons for assessing access to health care (Kohli, Sahlén et al. 1995). In this research we used drive time and least cost path analysis model to calculate access to primary health care services. Recent advances in the computational ability of GIS and availability of data have enabled the model of least cost path analysis to be an option. The network analysis in Arc Info 9.1 was used to generate best route or shortest time from population residence area to PHC services (destination points) and to calculate the serviceable areas. To calculate travel time and travel distance, road fragment length is required and this was computed with ARC/INFO(Environmental Systems research Institute 2005).

Since the population is not distributed uniformly across a Meshblocks polygons, instead of using simple geometric meshblock centroids as a demand points, in this study, the mean centre of population distribution was calculated and called the origin locations (demand) and the PHC facilities were considered as destination points (supply).
Travel time was estimated as the shortest time through road networks between any pair of population and PHC locations. There are many factors, for example, road type, topology, day of time, urban or rural road, land use, season and sinuosity that affect on estimating road travel time.

In this research, we estimated drive time for road network based on road surface- types, number of lane, sinuosity index and rural and urban land use. To calculate the sinuosity index, two variables are required, the observed length and the expected straight length (Haggett and Chorly 1969) With ARC/INFO it is easy to calculate the observed length line for road network data sets. But, to calculate the straight length, we had to generalise the original road layer by removing vertices from the road segments and there was only one vertex per 500 m tolerance. After simplifying the road layer, the lengths were calculated and called expected straight line. The new lengths joined to the original road data sets by common ID field in ARC/INFO 9.1 (table 1). If observed length divides by expected direct length, the result will be sinuosity index. The sinuosity index is ranges from 1to 6. Roads with sinuosity of 1 will be straight and if the road is bendy then the sinuosity index will be greater than 1.

Attributes of road_cl_Otago_NZMG

STATUS	LANE_COUNT	HWAY_NUMBE	ROAD_IMAGE	WAY_COUNT	NAME_ID	Length	Drive_Time	SinusIndex
	1					0.790665	0.952600	1.001089
	2				1030000036272	3.153251	3.799098	1.000151
	1					0.015742	0.023852	1.020673
	2				1030000186972	1.441550	1.736808	1.009409
	1					1.209727	1.832920	1.033619
	2				1030000036495	1.776927	2.140876	1.000764
	2				1030000035792	0.456264	0.549716	1.032474
	1					0.407994	0.491559	1.016431
	2				1030000036495	0.756470	0.911409	1.006971
	2				1030000036197	0.338553	0.407895	1.000038
	2				1030000026559	2.490523	3.000630	1.000749
	1					1.138438	1.371612	1.006435
	1					0.202561	0.244049	1.002432
	1					0.571040	0.688000	1.029767
	2				1030000003860	1.101140	1.326675	1.016767
	2				1030000036229	1.365437	1.645105	1.000016
	1					3.309920	4.004250	1.016081
	1					0.866696	1.044212	1.056446
	2				1030000036114	1.489648	1.794757	1.000117

Record: 3 Show: All Selected Records (0 out of 11473 Selected.) Options

Table 1: Joining the sinuosity index to original road layer

Drive time was estimated for each road ARC as follows:
- Sealed, 2 lanes, rural straight roads- average speed 80 km/h
- Metalled ,2 lanes ,rural, bendy roads-Average speed 60 km/h
- Metalled, 1 lane, rural, straight roads-average speed 60 km/h
- Metalled, 1 lane, rural, bendy road-average speed 40 km/h
- Un-metalled, rural, bendy roads-average speed 30 km/h
- Un-metalled, rural, straight roads-average speed 45 km/h

- High way –average speed 80 km/h
- Sealed urban roads-average speed: 30 km/h

This categorisation of road speeds would alter based on speed setting rules of each country. It is easy to changes theses values, they are just limits. However, drive time is estimated and there are some limitations for setting speeds for each road segment. For example this estimation does not take into account different time of day, traffic congestion, different seasons and mode of transportation. As a result, estimated travel time can not provide the real travel time of people.

3.0 RESULTS

3.1 Best route (shortest time)

The best route (shortest time) from mean centre of population location inside of each meshblock to Primary health care facilities is presented in the Figure 2.

Figure2: Best route (shortest time) from residential area to PHC services

Above figure only represents shortest time to reach a closest PHC facility from mean centre of population distribution (incident) for one meshblock. The best route was created by using network dataset and Network analysis in ARC/INFO 9.1. The best route will be shortest distance if we use distance as a impedance and for travel time it will be shortest time to reach a facility from residential area (Environmental Systems research Institute 2005). The time of travelling from residence area of meshblock (3021700) to PHC location (11) are generated as a separate field in the attribute table of best route and in this example is 8 minutes.

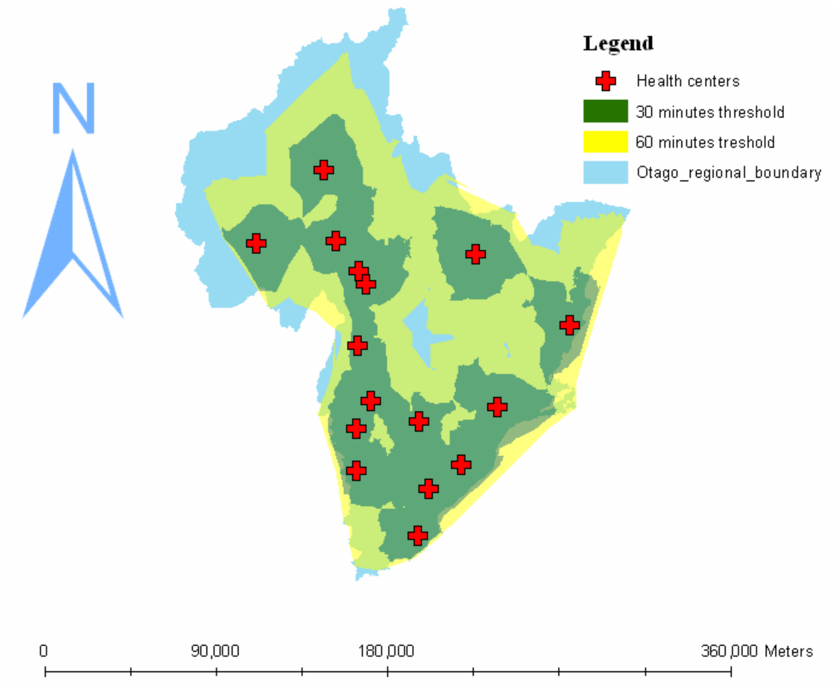

Figure 3: Finding 30 & 60 minutes threshold travel time to PHC services

3.2 30 & 60 minutes threshold travel time

According to New Zealand health policy as mentioned before, 95 percent of population should be able to access health care facilities within 30 minute drive time during business day and after hours with 60minutes travel time. As the figure 3 shown some parts of Otago region do not meet the New Zealand and WHO policies. Capability of network analysis in ARC/INFO 9.1 was used to computing service area for 32 PHC facilities and 30, 60 and more than 60 minutes polygons were generated respectively.

People living in central and northern parts of Otago province have less accessibility to primary health care.

4.0 DISCUSSION & CONCLUTION

The aim of this paper was to test a new accessibility approach generate an accessibility index for PHC. Spatial accessibility is this paper is only part of realised accessibility (based on the five types of categorised barriers). We intend to develop our approach with consideration of non spatial factors such as deprivation indexes, ethnicity, education, gender, age, income, housing and transportation mode and then combining spatial and non spatial in one frame to evaluating accessibility of PHC.

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