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Population need and geographical access to general practitioners in rural New Zealand

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Abstract

Aims To use a geographical information system (GIS) approach to demonstrate the extent to which different areas in New Zealand vary in their geographical access to GPs, and to analyse the extent to which spatial access varies in relation to different population groups.

Methods Three methods; population/GP ratios, least cost path analysis (LCPA), and an allocation method (which considered the capacity constraint of GPs) were used to demonstrate differences in geographic accessibility to GPs. Travel time, and distance to the closest GP, was calculated for every census enumeration district in New Zealand (n=38336)—thus enabling population-based accessibility statistics to be calculated and aggregated to the territorial local authority level. These calculations include the average travel time if everybody visited a GP once and the population more than 30 minutes from a GP. The composition of this population is analysed according to three criteria of need: the level of deprivation (NZDep2001), ethnicity (%Maori), and age (% <5 years, and %65 years and over).

Results There are significant regional variations in geographical accessibility in New Zealand, and these differences are dependent upon the method to calculate accessibility. Ratio measures give a different picture of GP access than the other two indicators, reflecting the fact that TAs with similar ratios often have wide variations in travel times as well as the size and proportion of the population living more than 30 minutes from the closest GP. TAs with larger numbers and a higher proportion of their populations living in such areas tend to be more deprived and have a higher proportion of Maori, especially in the North Island. There appears to be no significant trend by age.

Conclusion Given the health and service consequences of poor access, the results suggest that more attention needs to be paid to extending the spatial information base in primary care, in order to achieve more effective planning of services for disadvantaged populations.

Accessible and appropriate health services for people living in rural areas remains an issue of ongoing concern. The implementation of the *Primary Health Care Strategy*, together with the more recent development of primary health organisations (PHOs), both build on earlier government policies designed to improve the level and continuity of service provision in rural areas.[1,2] While such developments provide an opportunity to improve the effectiveness and sustainability of rural primary health care services, a number of important questions remain. These include problems of funding rural care, difficulties in attracting GPs and other health professionals to isolated rural areas, problems of high doctor turnover and continuity of care, as well as the influence of geographical and financial barriers, which may serve to limit the utilisation of needed services.[3,4]

New Zealand, with its rugged physical environment and dispersed rural population, poses particular problems for the location and use of services. An important requirement, therefore, is to develop quality information systems that highlight the physical accessibility of primary care, and the extent to which this access varies for particular rural population groups.[5]

Improving the quality of information on accessibility to rural primary health care is also an important requirement for effective decision-making by PHOs and District Health Boards (DHBs). The objective of this paper, therefore, is two-fold:

- To use a geographical information system (GIS) approach to demonstrate the extent to which different areas in New Zealand vary in their geographical access to GPs, and
- To analyse the extent to which spatial access varies on the part of different population groups.

The Rural Expert Advisory Group's report, *Implementing the Primary Health Care Strategy in Rural New Zealand. A Report from the Rural Expert Advisory Group to the Ministry of Health*, has indicated that high levels of deprivation are a feature of some rural regions in New Zealand, and that the extra travel costs that rural people incur make access to primary health care services particularly difficult for the people of these communities.[6]

Therefore, an important task is to identify those areas where problems of physical accessibility to GPs are compounded by increased needs for care and conditions of rural disadvantage.

Methods

A geographical information system (GIS) was used to measure geographical (physical) accessibility to GPs. Three key methods were compared. First, population/GP ratios were calculated for each of the 73 Territorial Local Authority areas in New Zealand (using full-time equivalent GP data for the year 2000 provided by the Ministry of Health and population data from the 2001 Census).

Second, since population/GP ratios are only a crude measure of geographical access, two further methods were used: least cost path analysis (LCPA) and an allocation technique that considers the number of GPs available and how many people a GP can service. Both methods represent an improvement on traditional ratio measures of GP access, as they involve more detailed calculations of travel distances and travel times. In addition, they are not constrained by area boundaries and aggregation problems of ignoring the intra-district location of GPs relative to their patients.

LCPA involved calculating a least cost path algorithm to determine the shortest travel distance and time between each of the 38,336 census meshblocks (origin nodes) in New Zealand, as well as the closest GP practice (destination nodes). Network analysis capabilities in ARC/INFO were used to calculate accessibility. The *nodedistance* command computes distances between all possible combinations of origin and destination nodes via the New Zealand road network.

In this study, nodes closest to the meshblock centroids were the origin nodes and nodes closest to GP practices (n=1390 practices representing 3614 GPs) were the destination nodes.

To identify the closest GP for a given Census centroid, we calculated the minimum distance for each origin to each destination. The minimum distance to the closest GP for each centroid was the sum of three calculations; the network distance, plus that from the meshblock centroid and GP surgery to their closest road nodes, respectively.

The process for calculating the minimum travel time to the closest GP is similar, except road travel time is used instead of distance. Estimated road travel times were based on whether the road was inside or outside an urban area, number of lanes, condition of the road surface (sealed versus unsealed), and the bendiness (sinuosity). The road travel times, while similar to those published by the New Zealand Automobile Association, do not take account of the effects of travel congestion or seasonal differences. Full details of their derivation and limitations are given in Brabyn and Gower.[7]

Since the population characteristics of each Census meshblock are known, it was also possible to calculate average travel times. This was accomplished by multiplying the population of each centroid by the travel time of the centroid (to determine the total time spent travelling if everyone represented by the centroid visited the closest GP once). To calculate the total travel time, these values were then aggregated to the level of the TA. The average travel time was obtained by dividing this total by the TA population.

While LCPA approaches represent an improvement on ratio methods of determining geographic access to GPs, they can be misleading because not all patients choose to use the closest GP.[8] LCPA, therefore, provides estimates of optimum rather than actual travel distances and times. Furthermore, it ignores the fact that some GPs have multiple practices, especially in rural areas where these may also be partly staffed by other health professionals for part of the time. LCPA also neglects the capacity of a GP practice to service the surrounding population.

Many people may be unable to get an appointment because the GP is servicing a large population and hence may choose another provider, especially in more densely populated areas where other alternatives are available. Despite this caveat, an allocation method was also used to estimate variations in GP access. This involved allocating potential patients to the closest GP practice until the practice reaches a specified capacity level. The model then finds the next closest GP practice. Once a population has been allocated a GP, the network travel time and distance is calculated.

The capacity used in this study was 1400 patients per full-time GP—which is the number used by the Ministry of Health for a full-time work load.[9] The output from the allocation method is similar to LCPA except for the addition of a capacity constraint. However, the allocation method is also limited because of its assumption of a uniform capacity constraint, which clearly varies between GPs especially depending upon their gender and age.[10]

Both the LCPA and allocation analyses enabled estimates of the total population with poor geographic access to GPs to be calculated. For the purposes of this analysis, a 30-minute threshold was chosen. Thirty minutes is a long time to travel to a GP and, given the results of US research,[11] most persons would have expressed dissatisfaction at having to travel for this length of time.

The three methods are first compared, followed by the analysis of the population composition of rural areas remote from GPs. Four measures of population need are considered; the 2001 New Zealand Deprivation Index (NZDep2001[12]), the proportion of the population of Maori ethnicity, and two indicators of age (percentage less than 5 years old, and the percentage aged 65 years and over). These measures enable the assessment of population groups that are particularly vulnerable to poor geographical access.

The method outlined above contains generalisations that can skew the results but are necessary for practical reasons. First, meshblocks are represented by one central point, and the location of this point may not accurately depict the population distribution within the meshblock (which will be a problem with large rural meshblocks found in the South Island). There is a new data set being developed in New Zealand (called LandOnLine) that contains address points, which will map the location of every letterbox in the country. This data set has been completed for many TAs and can be used to represent the population distribution within a meshblock.

Preliminary analysis using the geographical mean of the address points within a meshblock shows that travel times are 2–3% less than with meshblock centroids. Therefore, the method used for this study overestimates travel times for rural areas. The second generalisation used by the method is that it only considers travel speeds during normal flow and does not consider traffic congestion that is happening in urban centres during rush hour traffic.

A temporal dimension to accessibility would be a worthwhile research endeavour if data on travel speeds at different times of the day were known.

Results

Comparison of the three techniques as indicators of GP access—Figure 1 shows the population/GP ratios by TA, while Figures 2 and 3 show the population more than 30 minutes from a GP using the LCPA and allocation models.

Figure 1: Population (by territorial authority) per GP

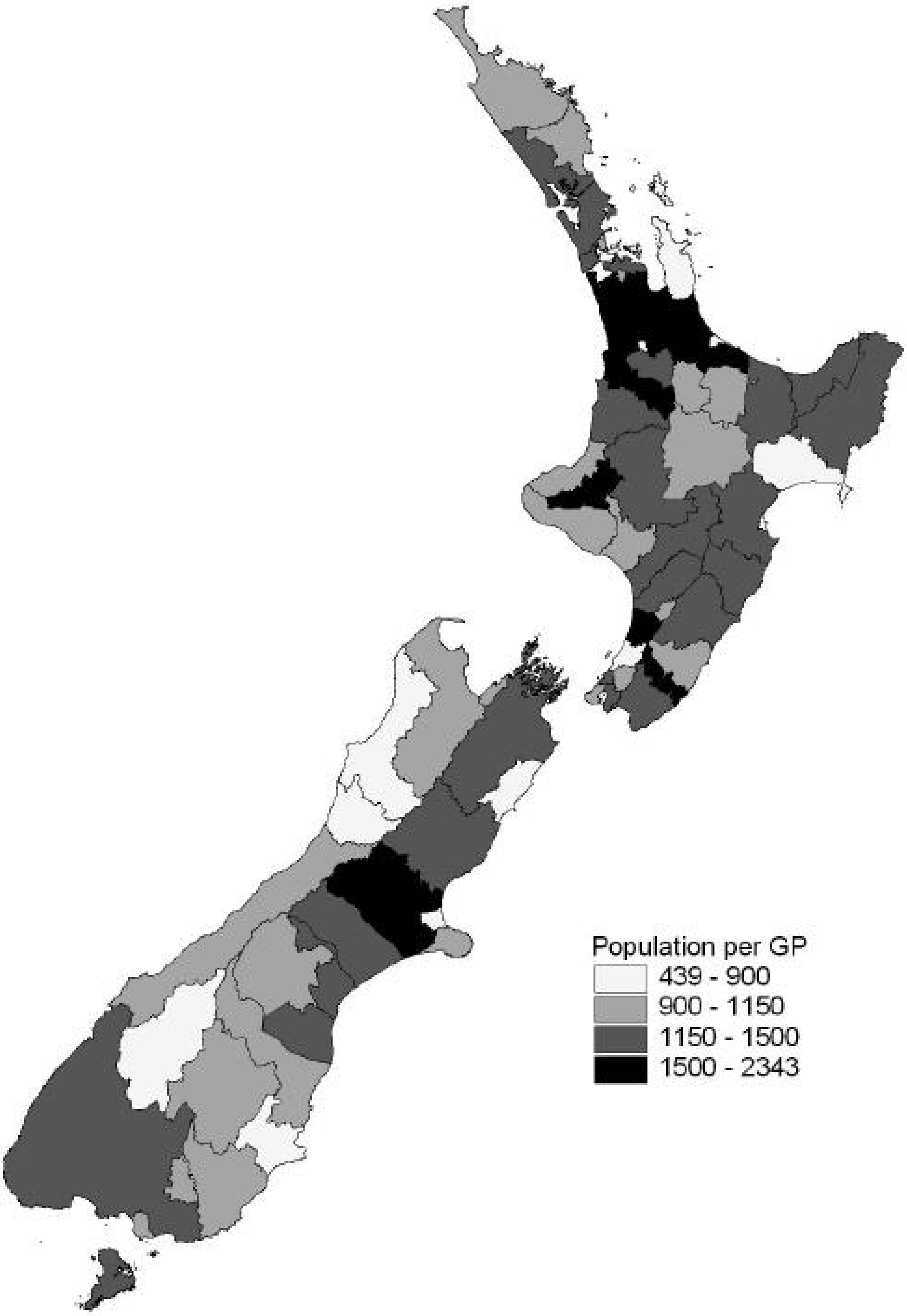


Figure 2: Population (by territorial authority) more than 30 minutes from a GP; using LCPA (least cost path algorithm)

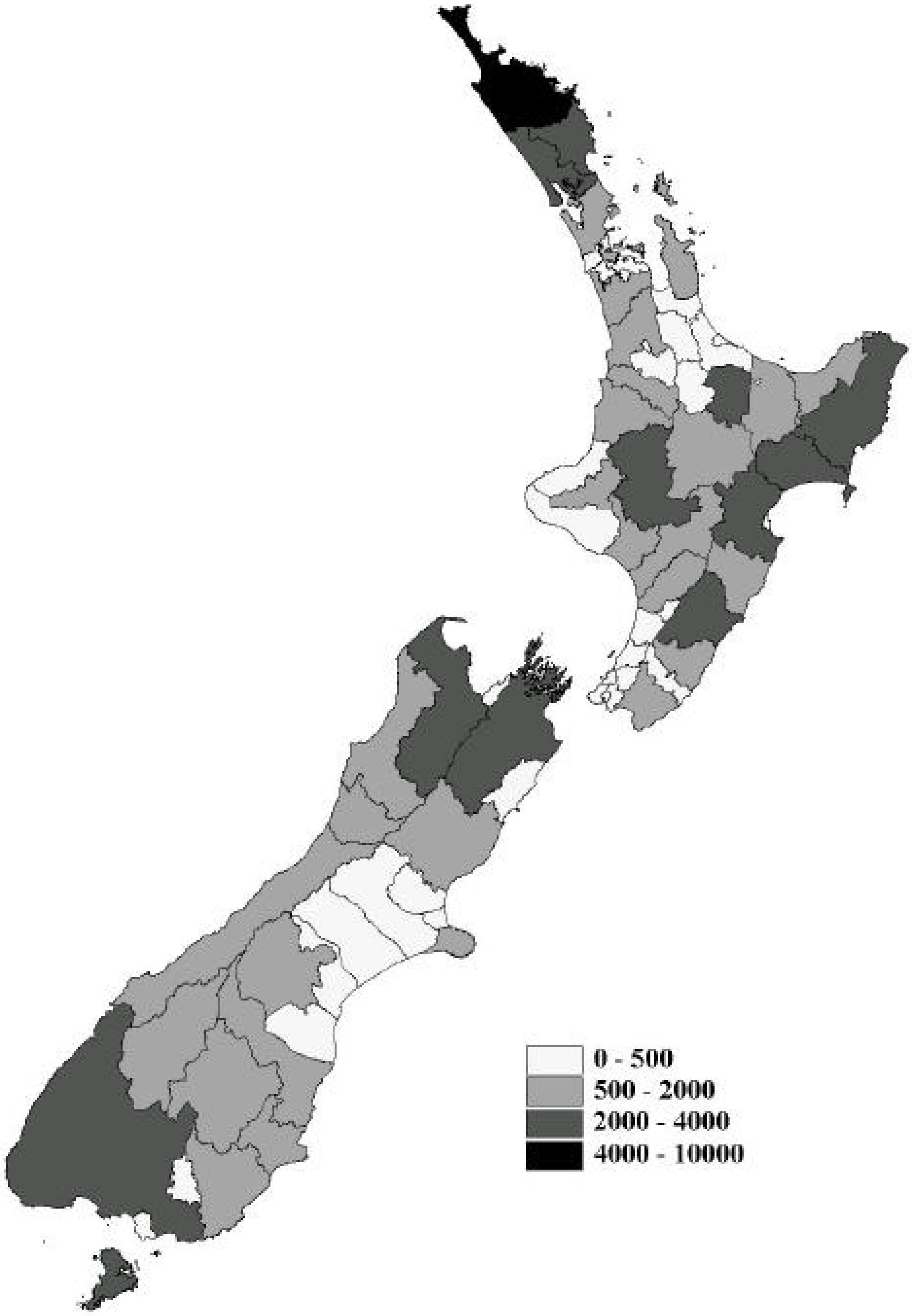
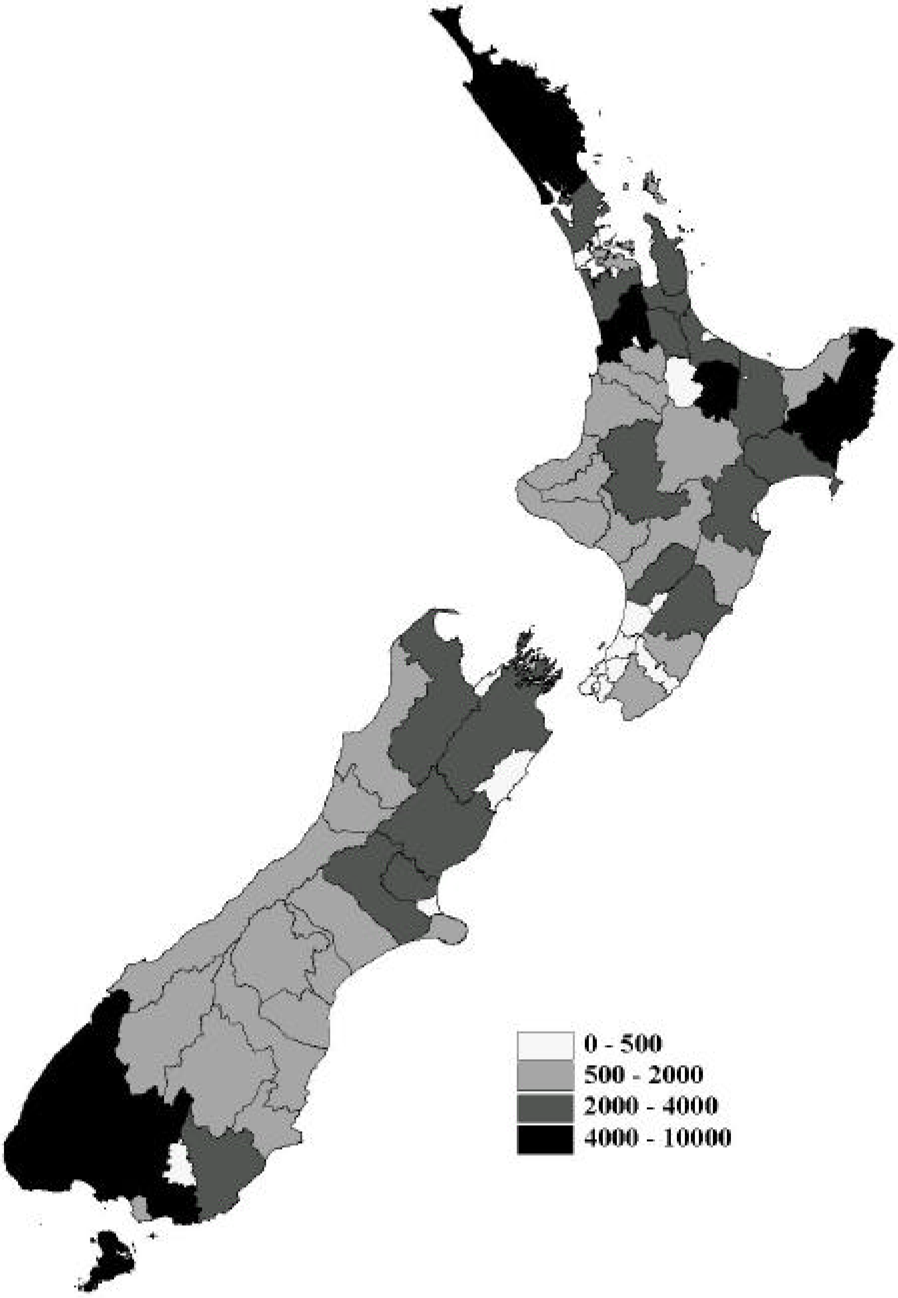


Figure 3: Population (by territorial authority) more than 30 minutes from a GP; using an allocation model



There are many other statistics that can be generated from the LCPA and allocation models (including the average travel time, total travel time, and travel distance); however, these statistics can be misleading as the average travel time does not consider the population affected by this time.

Furthermore, a region may have a high average travel time but only have a low population. For example, Westland District has a high average travel time (20.8 minutes—based on the allocation model) but only has a population of 8,091.

It would therefore be inappropriate for the Government to use only average travel time as a basis for funding. It is possible to present the total travel time for each district and use this for a comparison. However, this statistic is high for populated cities because of the large populations even though the average travel times are less than three minutes. The population more than 30 minutes from a GP is therefore the preferred statistic to use when representing geographical access.

The results generated from the LCPA and allocation models can be represented at a range of scales from individual meshblock units to national statistics. The average travel time to the GP for the whole of New Zealand is 4.6 and 5.9 minutes for the LCPA and allocation models respectively.

The population more than 30 minutes from a GP for the whole of New Zealand is 70,833 and 122,034 for the LCPA and allocation models, respectively. To compare regional variations in accessibility across New Zealand, it is necessary to choose a scale where the number of regions is manageable, and where the regions are not too large so that important variations within a unit are generalised.

Figures 1, 2, and 3 were compiled according to territorial authority (TA) regions, which is a good compromise. District Health Board regions could also be used but these cover large areas and there are significant variations within them as shown by the territorial authority scale.

A visual comparison of the models (Figures 1–3) shows that they all provide a different representation of access. Specifically, there is weak correlation between ‘population per GP’ and the LCPA and allocation models (0.14 and 0.17, respectively). However, this is to be expected given that they are completely different methods for measuring accessibility.

Population per GP does not consider the distribution of the population or the GPs within a particular TA whereas the LCPA and allocation models are not constrained by area boundaries in the same way that the population per GP method is. Rather, times from GP locations to the closest population enumeration point are calculated. The effect of this difference can be seen in the comparative results for Waikato District. Using the population per GP method, Waikato District has the highest ratio (2343 people per GP). However using LCPA and calculating population (more than 30 minutes travel time from a GP), the district is mid range in its accessibility (33 out of 73).

This disparity is because many of the GPs that service the Waikato District are located in the city of Hamilton and towns of Cambridge and Morrinsville, which are all within 8 km of the Waikato District boundary. Waikato District is predominantly a rural district that is serviced by Hamilton City, which has its own TA status. This detail is neglected in the ratio method.

There is a strong correlation between the LCPA and allocation models (0.88), which is expected since the methods are similar. Where there is a significant variation between these models, then this indicates that functional access is a problem.

Selwyn District and Waikato District have substantial differences between these models (3432 and 3303 people respectively) and there are 17 TAs with differences between the models of over 1000 people. All these TAs can be characterised as rural. Virtually all the major urban TAs have no difference between the LCPA and allocation models. As expected, the population more than 30 minutes from a GP using the allocation model is either equal or more than the LCPA model.

The LCPA and allocation models use travel time that only includes actually time spent travelling by car and not time spent loading the car and finding a park. The travel time in cities appears very low but the travel distance is on average less than one kilometre. It needs to be emphasised that this analysis is intended to produce general statistics rather than assessment of individual travel times.

LCPA and allocation models produce results that clearly differentiate between urban and rural districts. Urban territorial authorities have low travel times, as there tends to be many GP services within a sort distance. Conversely, high travel times in rural districts describe the dispersed characteristics of populations and concentrated GP locations in provincial towns.

Variations between rural districts reflect differences in population distribution, which in turn is related to land-use, livelihood, and topography. For example, the Far North District is long and narrow with a large population living outside of service towns. Conversely, the Waikato District has a high rural population but also a high number of service towns.

GP access by population group—While rural regions are more likely to have problems of access to key services, an important question is the extent to which problems of GP access vary between TAs depending upon their population characteristics. LCPA and allocation models combined with the NZ Deprivation Index (a score of 10 is the most deprived) and census data has been used to produce a range of statistics for different ethnic, age, and deprivation groups—and this was completed for each TA and DHB.

This produces large tables that are not possible to present in a journal publication. Table 1 was generated from the allocation model and provides a sample of this data. It includes the Far North District and Southland District, which have the highest population that is more than 30 minutes from a GP. They are also geographically separated as they are at opposite ends of the country. For comparison, Table 1 also shows two urban TAs (Waitakere City (which is part of Auckland), and Christchurch City) and statistics for the whole of NZ. The average travel time for the different population groups is also presented.

At a national level, there are variations in geographical access for the different population groups; however these do not appear to be significant (this is statistically demonstrated in Table 2, which is discussed later).

If people are split into two groups—wealthy (NZ Dep 1-3) and poor (NZ Dep 8-10)—then it can be said that wealthy people generally have higher travel times to GPs (as many wealthy people purchase lifestyle blocks on the outskirts of cities, and due to the existence the wealthy farming communities.

Table 1. Accessibility to GPs by different population groups

(Click here to view Table 1)

Elderly people generally spend less time travelling to their GP and this can be explained by the deliberate move many retired people make to be closer to health services. The under 5 years group appear to be close to the average. Maori people have higher travel times, on average, which can be explained by the rural nature of many Maori communities. As for Pacific Islanders, they have less travel time (on average), and this can be explained by the large, urban Pacific Island population in Auckland.

When different TAs are studied, there can be significant variations to these trends. It is clear from Table 1, that there is no significant problem with geographical access for any of the population groups in the two urban TAs, both in terms of the absolute number of people and as percentages. This is the case with all the urban TAs. In the Far North District, there is a complete reversal of the national trend in terms of wealthy and poor people, although the absolute population of wealthy people is low (2454). However, Southland District supports the national trend.

Table 2 illustrates correlations between three measures of GP access and the socioeconomic characteristics of all TAs, and also provides a separate analysis of the North and South Islands. Regarding average travel times to GPs, it is clear that rural areas with lower population densities have poorer accessibility, as do areas with larger Maori populations, especially in the North Island.

By contrast, TAs with the highest concentrations of more affluent groups (deprivation deciles 1-3), in general, had shorter travel distances to care than was true for more deprived populations (deciles 8-10). TAs with concentrations of older people (65 years and over) also had smaller average travel times to GPs, but only in the South Island.

These patterns are also evident with respect to the two other access measures (the % total population more than 30 minutes from a GP based on LCPA and allocation methods). However, here the correlations are magnified between poor access and levels of deprivation and ethnicity, especially in the North Island. In contrast to the travel time analysis, in both cases, the relationship between (poor) levels of geographical access and deprivation is strong (r=-0.57 and -0.55) for the LCPA and allocation measures, respectively.

These patterns are illustrated in Figures 2 and 3, which show the absolute population more than 30 minutes from a GP in different TAs and compare the LCPA and allocation techniques. The pattern is a predictable one. Many of the traditional Maori heartlands, such as Gisborne or the Far North, have larger populations with poorer access, but so do many of the more remote southern TAs such as Southland or Marlborough.

For New Zealand as a whole, the LCPA analysis indicates that 70,833 people (or 1.9%) resided more than 30 minutes from their closest GP. This figure rises to 128,034 (or 3.4%) when the results of the allocation analysis are examined. While the latter figure may not seem particularly high (3.4%), the proportion of the population with poor access rises to 9.9% for all rural TAs (those outside the main metropolitan areas and regional cities), and exceeds this margin for over half (24) of the 45 more rural TAs

(Click here to view Table 2)

Discussion

The results presented here suggest that problems of GP access remain important for many of the more remote rural areas in New Zealand. Many people in these areas suffer a double burden. Not only do they face long travel times for obtaining primary care, but also since they are often deprived, travel difficulties are accentuated.

Other research has indicated that the economic costs of obtaining care represent a significant deterrent to low income people in New Zealand.[13,14] Malcolm[13], for instance, in a survey of eight health centres providing services to Maori and low-income New Zealanders, found that rates of GP utilisation were substantially lower (from 37 to 74%) than the national average of 4.5 visits per capita in 1994/95. But, given that the centres were set up to improve access to Maori and low-income populations, and had significantly reduced the financial barriers present in the average general practice, then cost barriers alone did not appear to be a major factor for the very low rates of utilisation observed; the effects of geographical and cultural barriers were just as important.

Although the present study did not examine GP utilisation rates in areas remote from GPs, Malcolm's results are consistent with a large, and longstanding, geographic literature demonstrating links between geographic barriers and utilisation rates (both for primary and hospital care). For instance, Haynes and Bentham[15] found that GP consultation rates, outpatient attendance rates, and inpatient admissions in Norfolk (UK) were all found to decline with decreasing accessibility.

The groups most affected in rural areas were those with the highest relative need for healthcare. Other research has similarly found that distance barriers disproportionately affect poorer patients.[16] For higher-status patients, distance barriers will have less effect on utilisation not only because of greater levels of affluence and car ownership, but also because of a preference to take advantage of non-local providers of both primary and hospital care.[17]

However, as Girt[18] and others[19,20] have found, distance may have both a positive and negative effect on consulting behaviour. Individuals are likely to become more sensitive to the development of disease the further they live from a doctor, but (at the same time) distance negatively affects their propensity to consult. The distance at which this effect changes seems to depend upon the extent of the self-perceived illness or condition.[20]

The effect of 'distance to GP' on 'rates of use' also has implications for the use of hospital services. In rural New South Wales, Walmsley[21] found that the chances of admission diminished the further a patient lived from hospital. Haynes et al[22] similarly found that (after controlling for needs and provision) distance to hospital produced a 17–37% reduction for different types of admissions.

Of particular importance was their finding that distance to GP surgeries had the effect of reducing hospital inpatient episodes—an effect which was greatest for elective and psychiatric admissions.

These findings suggest that 'distance' and 'travel time' are important considerations, especially for rural dwellers (who frequently express the greatest dissatisfaction with problems of access to care).[11] An accumulated body of research thus suggests that policymakers should give greater weight to such parameters when evaluating the availability and quality of primary care in rural areas.

Traditionally, analyses of future directions in primary healthcare have either neglected the importance of spatial analysis approaches[23] or, where analyses have taken place, they have been on the basis of crude GP population ratios.[24]. However, such an approach, on its own, is an insufficient basis for assessing the effects of poor access and planning future needs.

Population-based 'travel time' and 'distances to health services', as well as an 'analysis of the characteristics of the population most affected by geographic barriers' are more useful measures of GP accessibility—and we suggest that future primary healthcare policy should pay more attention to such factors. Such considerations will become more important as PHOs take on the task of identifying and addressing those groups in their populations that have poor health or are missing out on services.

The application of GIS approaches, such as those discussed in this paper and which are beginning to be widely used in health research,[25,26] therefore provide a valuable tool for assisting such organisations in improving access to services and the health of the most disadvantaged. The use of GIS tools, however, requires access to quality data. One of the most time consuming challenges of this research was obtaining a geographically referenced database of GP practices.

Currently the GP register maintained by the NZ Medical Council does not contain reliable information on the geographical location of GP practices. An address of each practice is kept, but this could be the GP's residential address. The addresses of GP practices were obtained from a commercial data supplier, whose usual clients would likely be pharmaceutical companies. The conversion of addresses to a GIS layer is labour intensive and should only be done once.

Lastly, it is imperative that the Ministry of Health or the New Zealand Medical Council maintains a geographically referenced data set that contains New Zealand grid reference coordinates of GP practices, along with the number of GPs working in the practice and the hours they work.

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