Research

Mapping access to health services as a strategy for planning: access to primary care for older people in regional Queensland

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Australia has seen a significant increase in people aged over 65 years accessing general practice services over the last decade. Although people aged 65 years and over comprise 14% of the total population, this age demographic accounts for the largest proportion of general practitioner (GP)–patient encounters. Access to general practice is important for older Australians as the burden of chronic disease increases with age. A geographic information system, ArcGIS, was used to assess geographic access to general practice for older people residing in the regional Queensland towns of Mackay, Townsville and Cairns. Geographic units with high proportions of over 65-year-old people were spatially analysed in relation to proximity to geomapped general practices with a 2-km buffer zone. Modelling of changes in access was performed with the strategic location of a new general practice where gaps existed. Geographic access to general practice for the older population was poorest in Cairns despite a high population density. Addition of a single, strategically placed general practice in Cairns markedly improved access. Socioeconomic analysis suggested that general practices were appropriately located in areas of greatest need. Geographic information systems provide a means to map population characteristics against service locations to assist in strategic development and location of future health services.

What is known about the topic?

- Ageing populations have a higher burden of chronic illness and increased health needs, leading to a priority focus on increasing access to primary health care for older people.

What does this paper add?

- Geographic Information Systems are an essential tool for strategic health service design at a population level that can be used to improve access to primary care for underserved populations.

Additional keywords: elderly, general practice, GIS.

Introduction

Inequitable health outcomes linked to poor access and utilisation of healthcare services persist for regional, rural and remote populations in Australia (Health Workforce Australia 2012). In rural and regional Australia, access to general practice continues to be negatively affected by geographic and vocational maldistribution of the workforce, and this is forecast to continue to at least 2025 (Health Workforce Australia 2012). Population ageing, increased demand for services and decreasing hours worked by health professionals are all factors contributing to difficulty in accessing health services (Australian Government Productivity Commission 2005). Using average Australian general practitioner (GP) utilisation rates as a benchmark, the maldistribution of GPs by count nationally has been calculated at an oversupply of 1129 in major cities, and an undersupply of 639 GPs by count in inner regional areas, 423 in outer regional areas and 66 in remote areas (Harrison and Britt 2011).

In Australia, although people aged 65 years and over comprise 14% of the population (Australian Bureau of Statistics 2011*a*), they account for 32.5% of GP consultations (Britt *et al*. 2014). There appears to be an upwards trend in general practice utilisation by older people, as highlighted by a significant increase in the proportion of GP–patient encounters for people aged over 65 years in 2014 compared with 2004 (Britt *et al*. 2014). Furthermore, patients who attend general practice frequently (more than 12 visits per year) are more likely to be aged over 65 years and reside in areas with greater socioeconomic disadvantage (National Health Performance Authority 2015).

Access to general practice is important for older Australians in the management of their health, as they encounter health conditions commonly related to ageing (Australian Institute of Health and Welfare 2014) and a high burden of multi-morbidity in terms of chronic disease. In 2005, the *Bettering the Evaluation and Care of Health* (BEACH) study found that 83.2% of patients aged 75 years or older attending general practice had experienced at least one chronic condition, with 58.2% having three chronic conditions (Britt *et al.*2008). Accessible primary health care provides the most effective and affordable management of long-term health and chronic health conditions (Starfield *et al*. 2005).

Increasingly, better health outcomes are attributed to the linkage of a patient with a ‘medical home’ that provides more accessible, comprehensive, coordinated and better quality primary health care (Rosenthal 2008; Aysola *et al*. 2013; DePuccio and Hoff 2013; Moureaux *et al*. 2015). Medical

homes use a variety of tools and interventions to: provide a team-based, comprehensive approach to a wide spectrum of health needs; promote coordinated care across the health system; offer more accessible services; and improve quality and safety (Jackson *et al*. 2013). In Australia, support for the medical home model of care is growing and many GPs are already applying elements of the medical home model of care in their daily practice (MacKee 2015).

Accessibility is an important component of the quality of primary health care services, and is often conceptualised in terms of availability, appropriateness, acceptability and affordability of care (Campbell *et al*. 2000; World Health Organization 2008; Levesque *et al*. 2013). Physical access to general practice is often the first step in a patient's health journey and as Levesque *et al*. (2013) discuss, involves service availability and accommodation, as well as patient-related dimensions (i.e. ability to: perceive health care need, seek, reach, pay for and engage with services).. Access to general practice may be challenging for older people because of deteriorating health, diminished physical and social mobility and limited financial capacity (Australian Institute of Health and Welfare 2014).

Health workforce analyses are often limited to larger geographic areas such as Divisions of General Practice, Medicare Locals, Primary Health Network catchments or Local Government Areas. However, the use of geographic information systems (GIS) to map healthcare services within smaller Census areas has enabled more detailed analyses of access (Kruger *et al*. 2011; Tennant *et al*. 2013). An Adelaide investigation using GIS mapping found inequitable spatial distribution of GPs for residents related to distance from the city centre and residents' socioeconomic status (Roeger *et al.*2010). Variation in healthcare access was also shown in a study that used GIS to map proximity to dental clinics in Western Australia, revealing disparity in access to dental care for those residing in areas of lower socioeconomic status in metropolitan and non-metropolitan Perth (Kruger *et al*. 2011). GIS has also been used to map chronic heart failure (CHF) management programs, highlighting difficult access to these programs in rural and remote areas where 20% of CHF patients were estimated to reside (Clark *et al*. 2007). Detailed GIS analyses can provide health workforce planners with practical information to inform their decision-making (Dulin *et al.* 2010; Masoodi and Rahimzadeh 2015).

Knowing that older Australians have a great need for GP services, the aim of this study was to assess equitability of spatial access to general practice for older people. The analysis focussed on three regional centres in north Queensland and specifically considered areas that were home to large proportions of older people to assist in the planning of future services. A secondary aim was to assess the utility of this GIS methodology for future health services planning in the northern Australian context.

Methods

All statistical and geographic data used to inform this study were accessed through open access resources. Ethical approval to conduct the study was not required. This study used the GIS software package ESRI ArcMap 10.1 (Environmental System Research Institute Inc., ESRI, Redlands, CA, USA) to map general practices in the study area. Spatial analysis investigating the proximity of general practices to areas with high proportions of over 65-year-old people was conducted (given that this age group accounts for a large proportion of GP encounters in Australia). Relationships between identified areas of inadequate access and levels of relative socioeconomic disadvantage were also investigated.

Study area

The study focussed on the three largest regional centres of north Queensland (Australia); specifically Mackay, Townsville and Cairns (Table 1). The study area was restricted to the 'built up' areas of these regional centres so as not to confound the study with the added geographic health service access issues of rural and remote areas. The regional centres were defined based on the collation of statistical geographic units, specifically Statistical Area Level 1 (SA1) units, set by the Australian Bureau of Statistics (ABS) in the 2011 Australian Statistical Geography Standard (ASGS; Australian Bureau of Statistics 2011*b*). SA1 units contain populations between 200 and 800 people, with an average of 400 people in each (Australian Bureau of Statistics 2011*c*).

General practice locations

The addresses for each general practice within the study areas of Mackay, Townsville and Cairns were obtained from local telephone directories and entered into a database. Practice addresses were cross-checked with databases from the earlier Divisions of General Practice and, later (in early 2014), the relevant Medicare Locals. Further cross-checks of data involved telephoning 10% of practices at random to confirm their location and local practitioner verification of list accuracy.

The latitude and longitude coordinates of each practice address was obtained using a freely available batch geocoding website (Schneider 2013). Resultant geocodes were manually reviewed to ensure that coordinates fell within the correct geographic zone. The geocodes were then cross-checked for accuracy by overlaying the coordinates on a world street map available from ArcGIS Online (https://www.arcgis.com/home/), using ArcMap.

Cross-checks of general practice locations with the relevant Medicare Locals and local GPs resulted in removal of four general practices that no longer existed. A total of 15 practices were added to the list of general practice locations. It is important to note that there was a 1-year lag between compilation of the original list and cross-checking of the list. Upon finalisation of the list, 10% of practices were called at random to verify their location; all locations were found to be correct.

Population statistics and SEIFA data

All population data were obtained from the 2011 Australian Census online databases at the level of SA1 units, available from the ABS (Australian Bureau of Statistics 2011*d*). Data for the study were extracted by place of usual residence and collected for age by gender. Data pertaining to relative socioeconomic disadvantage in the study area were obtained at the level of SA1 units, from the ABS Socioeconomic Indexes for Areas (SEIFA), specifically the Index of Relative Socioeconomic Disadvantage (IRSD) (Australian Bureau of Statistics 2011*e*). Digital geographic boundary data at the level of SA1 units were also obtained from the ABS (Australian Bureau of Statistics 2011*f*).

Spatial analysis

To identify those SA1 units that were home to large numbers of older people, the related demographic data were examined and SA1 units with more than 10% of the population over 65 years old were identified. The population and SEIFA data were incorporated with the geographic SA1 units forming an information-rich layer in ArcMap (ESRI). Practice locations were layered onto the map and a 2-km boundary or buffer zone was placed around each practice.

Many older people experience limited mobility and access to public transport in these regional centres is often poor relative to metropolitan areas. The definition of good proximity to a general practice was informed by expertise within the research team. This definition is supported by findings from a study by Field and Briggs (2001), who reported that larger proportions of patients were increasingly impeded from accessing general practice as distance to a service from their home increased. The least impedance was experienced when the distance was less than 1 mile (~1.6 km). Therefore, good proximity to a general practice for the entire SA1 unit was defined as having a general practice within 2 km of the weighted mean centre of a SA1 unit within which that person resides. Subsequently, SA1 units found to have their weighted mean centre outside of a 2-km practice buffer zone were identified as having poor access. The population and IRSD data for each SA1 unit identified as having poor access were derived from the analysis. All spatial analyses were performed using geoprocessing tools available in ArcMap. Results were described using proportions with 95% confidence intervals and Chi-Square tests, as appropriate.

Results

Spatial analysis

Mackay was found to have the highest proportion of SA1 units with high numbers of older people but also the best access to general practices, when compared with Townsville and Cairns (Figs 1–3). Conversely, Cairns had the lowest proportion of SA1 units with high older populations and the poorest access to general practices. These results become more significant when the population density at each regional centre is considered (Table 2).

On average, SA1 units in all three regional centres were found to contain between 390 and 400 people per unit. However, differences existed in population density (population km^{-2}) at each regional centre. The average area of a SA1 unit in Cairns was the smallest of the three centres at 0.76 km^2. Despite having smaller SA1 units, people over 65 years old in Cairns were found to have the poorest geographic access to general practices of the three regional centres. The population density in Mackay was lower than that of Cairns yet, according to our analysis, Mackay had the greatest accessibility to general practices for older people. Townsville's population was spread over a much larger area than Cairns and Mackay; however, access to general practices in Townsville was almost as good as in Mackay.

As proof-of-concept for modelling targeted enhancement of services based on the GIS data of this study, a single theoretical general practice was placed amongst Cairns residential areas, which appeared to be inadequately served by existing practices. The proposed site was chosen to offer the highest effect based on consideration of gaps visually identified on the study map and proportion of older people residing in the area (Table 3; Fig. 4). The addition of a single general practice, on a main road into the identified area of need, decreased the number of older residents with inadequate access by 26%. Overall, in Cairns, the proportion of older people with adequate access to general practice was increased by 1.7% (217 people), to a level of access similar to that seen in Townsville.

Investigation of relative socioeconomic disadvantage in adequately and inadequately served SA1 units found that the proportion of units with adequate access to general practice increased as the relative disadvantage increased (Pearson's χ^2 for trend = 13.65, d.f. = 1, P = <0.001; Table 4).

Discussion

Access to primary health care is an important component in maintaining health and reducing healthcare costs for ageing populations. Information about ease of access to health services within population centres is important for effective health service planning, particularly in this era of increasing focus on high-quality primary health care within an identified medical home. In the context of this study, consideration of older people's ability to physically access services will be a core component of access to equitable primary health care at medical homes.

Geographic information systems can be useful planning tools for matching the available services with population characteristics (Coffee *et al*. 2012; McKernan *et al*. 2013; Yao *et al*. 2013; Jin *et al*. 2015). This study has mapped general practice locations against population demographics in the regional centres of Mackay, Townsville and Cairns, in north Queensland, Australia. Despite similar proportions of older residents, differences in access to general practices are evident for this age demographic in each of these locations.

The proportions of older people who have limited access to a general practice (defined as residing in a SA1 unit that has a mean centre greater than 2 km from the nearest general practice) was found to

be worst in Cairns. The importance of this finding is made more apparent upon consideration of the higher population density in Cairns compared with Townsville and Mackay. That is, despite people living closer together in Cairns (compared with Townsville and Mackay), geographic access to a general practice in Cairns was still poorer than in the other regional centres.

Geographic analysis of socioeconomic disadvantage for the older demographic is especially relevant given that over 70-year-olds are overrepresented in the lower (more disadvantaged) deciles of relative disadvantage (Pink 2011). However, owing to limitations of SEIFA data, this correlation between older people and areas of high socioeconomic disadvantage cannot be supported conclusively using our data. Our findings suggest that those residing within good proximity to a general practice experienced higher levels of disadvantage compared with those having poorer geographic access. It is possible that those identified as having poorer geographic access in this study may have somewhat better ability to access services that are further away than those with better spatial access; based on the assumption that those living in areas of advantage are more likely than those in areas of disadvantage, to own a car (Australian Bureau of Statistics 2014). Results of the analysis also imply that, in terms of health service location planning, general practices have become established in areas of greater socioeconomic disadvantage and, perhaps by association, health need. The significance of this association should be confirmed with a larger-scale study. However, the usefulness of the spatial analysis performed even at this smaller scale is evident.

Locations of future general practices in Mackay, Townsville and Cairns may be informed by similar spatial analyses. As the Australian population continues to age at an increasing rate, the burden of chronic illness on primary healthcare services will also increase. In 2009, 49% of 65 to 74 year olds reported suffering from more than five long-term conditions (a condition lasting more than 6 months; Australian Institute of Health and Welfare 2014) and in 2007, 78% of over 65 year olds reported having at least one chronic condition (Australian Institute of Health and Welfare 2014). This is reflected in health service usage by the older population, as reported in the 2011–2013 Australian Health Survey, where 96% of over 65 year olds reported consulting a GP in the preceding 12 months (Australian Bureau of Statistics 2012). Supporting the growing health needs of older people with increased and equitable access to primary healthcare services is essential. Herein, geographic access is an important foundational consideration in the strategic location of future health services.

In the local context, we found that Townsville and Mackay were reasonably well-served in terms of primary care for older residents, but future practice locations should be sought and carefully considered in Cairns. Our modelling showed that in Cairns, the addition of one strategically located general practice can make a significant difference by increasing geographic access for older residents (found previously to have poor access) by 26% or 217 people. Spatial analyses involving complex mathematical formulae have previously been developed to measure accessibility to health services (Mao and Nekorchuk 2013). Some studies have used spatial information to create accessibility

indexes for specific healthcare based on travel time and health service location (Coffee *et al*. 2012). Yet, evidence of the feasibility of real-world implementation of such methods for health service planning is lacking in the literature.

Through using GIS systems to map population characteristics against service locations, it is possible for urban planners and health service managers to strategically consider the location of future health services to best meet population need. Although in this analysis GIS was used to assess the distribution of general practices, it could also be used to assess the distribution of allied health or dental services. In the rural and remote context, ability to measure geographic accessibility in relation to population and health needs could contribute to: improved access to, and sustainability of, outreach services; effective delivery of specialised services; and better health outcomes overall for populations with inequitable access to healthcare services (Rodriguez *et al*. 2013; McKinnon *et al*. 2014; Zaman *et al*. 2014).

Strengths and limitations

There are many other factors that may affect an individual's ability to access general practice, including health professional availability, financial capacity, patient mobility, appropriateness and acceptability of individual services and other socially themed factors. Access to general practice, in terms of practitioner availability, is complex and involves several factors such as practitioners per practice (headcount and full-time equivalents), hours of operation and areas of expertise, all of which lie outside the scope of this study. The findings presented here are essentially a best-case scenario, describing accessibility assuming that factors such as GP availability are optimal and equal. Mathematical models have been proposed that may account for other factors that have potential to influence access (e.g. distance decay, transportation modes and routes, service supply), though trialling such models in this context lay outside the scope of this study (Luo and Wang 2003; Mao and Nekorchuk 2013; McGrail 2012 & 2014). This study provides an analysis of one component of service access, but implications in relation to overall general practice accessibility should be considered with care given the multifaceted nature of health service accessibility.

A strength of this study was that spatial analysis of the study area was conducted based on the smallest unit of statistical data available, making findings more appropriate for the local area. However, several pragmatic decisions were made based on assumptions that might affect the results reported in this small study. For example, geographic access to general practices was measured with Euclidean distance and provided an overview of the study area, disregarding distance by actual road route. A more detailed perspective may be gained through analysis of distance and travel time by road. Such analyses become increasingly feasible as travel route applications are developed and refined within GIS software. For the older population, travel time using the bus network may also be a

consideration. The usefulness of such analysis in the context of this study is questionable, given the minimal distance of 2 km used to define inadequate access.

In addition, assumptions were made to include the entire population of a SA1 unit as either within range (2 km) of a general practice or outside based on whether the weighted centroid of the SA1 unit was within the 2-km buffer zone. It was also assumed that residents would access the nearest general practice and that residents were not hindered by geographic boundaries such as creeks or rivers. Accurate identification of current, existing practices may be enhanced through use of the subscription-based online database, Medical Directory Australia Online (Australasian Medical Publishing Co. Pty Ltd, see https://www.mda.com.au/secure2.jsp).

Conclusion

Tools such as GIS will be increasingly useful for planners involved in health service design at a population level. Through combining population demographic and socioeconomic data with the location of existing services (and, in the future, health need data), areas of unmet need may be identified and highlight where additional services are required. In Australia, as Primary Health Networks are instituted and take on a greater role in regional needs-based health service planning, utilising geospatial methodologies to design services and evaluate effectiveness will be an important part of their tool kit.

Conflicts of interest

None declared.

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Fig. 1. Map of Mackay depicting distribution of Statistical Area Level 1 (SA1) units with high proportions of aged populations in relation to general practices.

Fig. 2. Map of Townsville depicting distribution of Statistical Area Level 1 (SA1) units with high-aged populations in relation to general practices.

Fig. 3. Map of Cairns depicting distribution of Statistical Area Level 1 (SA1) units with high-aged populations in relation to general practices.

Fig. 4. Placement of a single general practice in an area in Cairns found to have poor access for older people.

435 **Table 1. Description of the study area**

436 Data extracted from datasets available from the Australian Bureau of Statistics (2011*a*, 2011*d*). SA1, Statistical Area Level 1; N/A, not applicable

Total number of SA1 units	193	428	335	956
Total geographic area (km^2)	208.2	1080.0	254.3	N/A
Average geographic area per SA1 unit (km^2)	1.08	2.52	0.76	N/A
Total population	77285	167307	133912	378504
Total population over 65 years old	8321	16185	12925	37431
Proportion of total population over 65 years old (%)	10.8	9.7	9.7	9.9

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Table 2. Number of Statistical Area Level 1 (SA1) units and associated population figures for older people in the study area with specific reference to access to general practices

CI, confidence interval

	n/N (%) (95% CI)	*n/N* (%) (95% CI)	*n/N* (%) (95% CI)	*n/N* (%) (95% CI)
SA1 units with high **proportion** aged population/total SA1 units in study area	88/193 (45.6) (38.6–52.6)	173/428 (40.4) (35.8–45.0)	127/335 (37.9) (32.7–43.1)	388/956 (40.6) (37.5–43.7)
SA1 units with high **proportion** aged population and inadequate access to a general practice	8/88 (9.1) (3.1–15.1)	16/173 (9.2) (4.9–13.5)	18/127 (14.2) (8.1–20.3)	42/388 (10.8) (7.7–13.9)
Aged population [count] with inadequate access/total aged population [count]	296/8321 (3.6) (3.2 - 4.0)	746/16 185 (4.6) (4.3 - 4.9)	835/12 925 (6.5) (6.0-6.9)	1877/37 431 (5.0) (4.8-5.2)

Table 3. Change in access levels for older people living in Cairns based on the addition of one strategically placed general practice

	Prior to addition of proposed general practice *n/N* (%) (95% CI)	After addition of proposed general practice *n/N* (%) (95% CI)
SA1 units with high-aged population and inadequate access to a general practice	18/127 (14.2) (8.1-20.3)	14/127 (11.0) (5.6-16.4)
Aged population [count] with inadequate access/total aged population [count]	835/12 925 (6.5) (6.1-6.9)	618/12 925 (4.8) (4.4-5.2)

Table 4. Comparison of the frequency of deciles for the Index of Relative Socioeconomic Disadvantage (IRSD) for adequately and inadequately served Statistical Area Level 1 (SA1) units

IRSD data extracted from the dataset available from the Socioeconomic Indexes for Areas (SEIFA) database (Australian Bureau of Statistics 2011*e*). For the IRSD decile, 1 indicates a high proportion of relatively disadvantaged people in the area and 10 indicates low incidence of disadvantage

IRSD decile (State)	SA1 units >2 km from a general practice (*n*)	SA1 units <2 km from a general practice (*n*)	Total SA1 units (*n*)	Proportion of SA1 >2 km from a general practice (%) (95% **CI**)
1 and 2	5	84	89	5.6 (0.8–10.4)
3 and 4	5	108	113	4.4 (0.6–8.2)
5 and 6	10	72	82	12.2 (5.1–19.3)
7 and 8	8	51	59	13.6 (4.9–22.3)
9 and 10	9	26	35	25.7 (11.2–40.2)
Total	37	341	378	9.8 (6.8–12.8)

[C]Some SA1 units were excluded as no SEIFA data were available from the Australian Bureau of Statistics owing to low population or poor quality data.