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The geographic distribution of patients seeking emergency dental care at the Royal Dental Hospital of Melbourne, Australia

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Background: Little detail is known about the geographical catchment areas covered by dental hospitals, with no previous Australian studies of this kind. The aim of this study was to assess the geographical distribution of public dental emergency patients and their socioeconomic status to define catchment zones for a dental hospital. ***Methods:*** All patients requesting emergency dental care at the Royal Dental Hospital Melbourne, meeting the inclusion criteria, in calendar years 2006 and 2010 were included in the sample. Geographic information systems tools were used to locate and link each patient address to the socioeconomic data. ***Results:*** For both 2006 and 2010 95% of the patients were living within 50km of the hospital. In 2006, most of the patients seeking care lived within a 15km radius of the dental hospital whilst in 2010 that distance increased somewhat. Patients from areas with similar socioeconomic status living more than 10km away from the hospital had poorer access to dental emergency treatment. ***Conclusions:*** The hospital had a surprisingly large catchment zone that overlapped those of smaller community-based clinics.

Key words: *density mapping, geographic information systems, GIS, health service mapping, geographic mapping, metropolitan hospitals*

Introduction

In Australia, dental services for adults are almost exclusively provided through user pays (fee-for-service) private practices. Eligibility for access to public dental care is means tested, limiting access generally to only those suffering poverty. The measure of poverty used for access differs slightly between States, but most use possession of a Health Care Card or Pension Card (issued by the Federal government) as the benchmark. Despite this safety net for care, significant inequalities in oral health still exist, and high levels of emergency care and tooth extractions have been reported by public dental clinics (Australian Institute of Health and Welfare, 2003; 2009). Cardholders aged 45-59 were shown to be four times more likely to be edentulous than non-card holders with no differences between urban, rural and remote regions for this age group. Cardholders were also twice as likely to not have made a dental visit in the last five years and nearly 70% of the cardholders attended private clinics at their last visit (Australian Research Centre for Population Oral Health, 2005).

Australia's second largest city (by population) is Melbourne, capital of the State of Victoria, in the southeast corner of Australia. Melbourne metropolitan area covers approximately 7,700km^2 and has a population of around 4.1 million (Melbourne Town Hall, 2011). Most public emergency dental treatment is provided by the Royal Dental Hospital of Melbourne (RDHM), a new purpose-built dental hospital in the city centre. In addition, a number of metropolitan-based small community clinics also provide care. Around 90% of all emergency patients at the RDHM have a health care or pension card, with a small minority being non-card holders. Those without cards are provided with care on a user-pays basis.

Although some previous studies focused on emergency dental access, little detail is known about the geographical catchment areas of dental hospitals, with no previous Australian studies of this kind. Information on local demographics, dental needs, dental providers and transportation options are necessary to plan for the effective delivery of public oral health services. Geographic Information Systems (GIS) are computer-based systems for the input, storage, maintenance, management, retrieval, analysis and output of location-based information. By illustrating juxtaposed multiple layers of information, GIS is emerging as an important novel tool in healthcare planning and understanding disparities locally, regionally, and nationally (Hyndman and Holman, 2001; Griffen, 2004; Borrell *et al.*, 2006; Dubowitz *et al.*, 2011; Kruger *et al.*, 2011). Internationally, GIS is now used in a variety of public health and social science applications (Kruger *et al.*, 2010). The aim of this study was to assess the geographical distribution of Melbourne residents requesting public dental emergency care and their socioeconomic status to identify catchment zones for a dental hospital.

Materials and Methods

Ethical approval for the study was obtained from the Ethics Committee of Dental Health Services Victoria (the organisation responsible for RDHM). All data were anonymised though unique patient identifier numbers were retained to identify duplicate events (i.e. a patient having more than a single emergency dental event).

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Included in the study were all patients requesting emergency dental care at RDHM that were triage classified as category 1 and/or 2 of the Emergency Care Demand Management System (ECDMS) from 1st of January to 31st of December 2006 and 2010. The ECDMS triage category 1 refers to patients with acute dental pain interfering with sleep the night before, patients presenting with swelling (gums, face, neck or mouth), patients unable to fully open mouth, accidents with patients under 14 years old, patients bleeding from recent extraction and all patients suffering from intellectual disability, immunosuppression and patients over 80 years old. Category 2 comprises patients with acute dental pain (caused by pressure/hot stimuli), and patients with dislodged or loose crown or bridge (Victorian Government Department of Health, 2009). Patients accessing services over weekends and/or public holidays were excluded as the dental hospital would be almost the only choice available out of working hours and that would bias the typical utilisation of the hospital. A few clinics are open on Saturdays and public holidays. Similarly, those triaged as categories 3, 4 and 5 were excluded as these relate to cases of lower urgency.

The address for each patient in the sample was entered into a database and the longitude and latitude of each address obtained through a free access geocoding system (Google Maps API). The accuracy level of this geocoding was used as a measure of integrity of the data. Only addresses geocoded to the "address" or "premise" level of accuracy were included in the analysis. Approximately 6% of the triage events were excluded due to a lack of geocoding accuracy. Patients with unknown residence address were also excluded (approximately 13% of the patients in 2006 and only 2% of the patients in 2010).

All population data were obtained from the Australia Census (2006) data. Population data were divided by census collection district (CD) and the geographic boundaries of each CD were obtained from the Australian Bureau of Statistics website (Australian Bureau of Statistics, 2012).

The Socio-Economic Indexes for Areas 2006 (SEIFA 2006) at CD level formed the basis of the measure of socio-economic disadvantage. The SEIFA 2006 is a composite measure derived from multiple weighted socio-economic variables collected in the 2006 Australia Census (Pink, 2006). This index includes variables that either reflect or measure material and social disadvantage. SEIFA 2006 values were ranked into deciles ranging from one (highest deprivation) to ten (lowest deprivation). Industrial areas and CD's for which no data was available are categorised as 'null' SEIFA.

Geographic boundary data for each CD was obtained from the Australian Bureau of Statistics, the population data and socio-economic data was geocoded using Quantum GIS (QGIS) - v1.7.4 (Open Source Geographic Information System licensed under the GNU General Public License). Analysis of geographic measures was completed using the QGIS software and minor results tallying were achieved using Microsoft Excel (v14.2.2).

Results

From the annual load of 22,710 emergency episodes triaged at the RMDH in 2006, and 37,715 in 2010, a total of 12,186 triage events in 2006, and 13,393 in 2010, met the inclusion criteria for the study. Although this study was designed to evaluate the access of Melbourne residents to RDHM, the high number of patients coming from outer Melbourne dictated that our study area was enlarged, therefore all patients residing in the State of Victoria were included in the analysis (Figure 1).

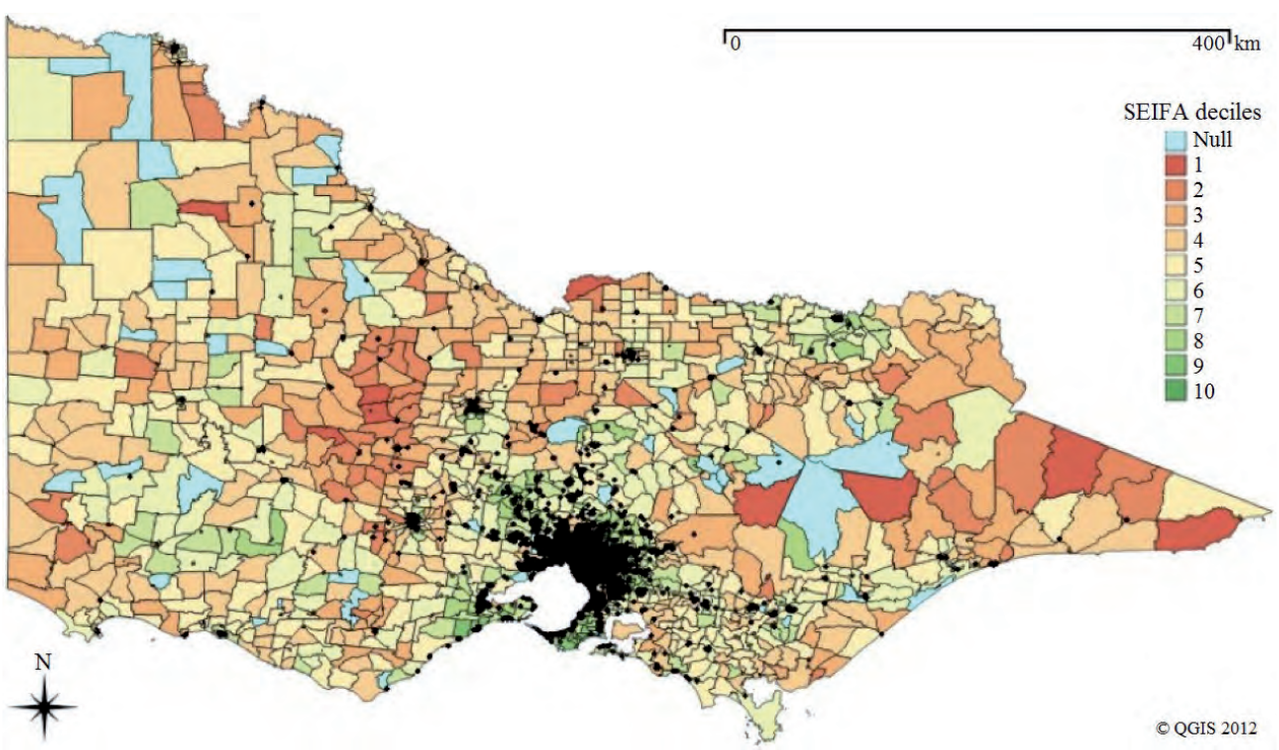

Figure 1. *The distribution of home locations of all dental emergency patients attending the Melbourne Royal Dental Hospital in 2006 and 2010 (black dots) across the state of Victoria with census districts colour-coded according to their socioeconomic status (SEIFA values)*

Access to emergency treatment was analysed as a factor of straight-line distance from home address to the RDHM. These distances were categorised as up to 5km, 10km, 15km, 20km, 25km and 50km and the proportion of patients living in each of these concentric areas recorded. The catchment zones were similar for both 2006 and 2010 RDHM utilisation (Figures 2a and 2b). The cumulative proportion of home distance to RDHM is presented in Table 1. For both 2006 and 2010 95% of the patients were living within a 50km radius of the RDHM. In 2006, most patients seeking emergency care lived within 15km of the RDHM whilst in 2010 that value increased somewhat.

A comparison of the socioeconomic status and distance from the patient's home to the RDHM is presented in Table 1. Approximately 70% of the patients living within 10km from the RDHM come from the least deprived neighbourhoods in Melbourne. Meanwhile, half of the patients living within 20km from the RDHM reside in the most deprived areas. Patients coming from the one

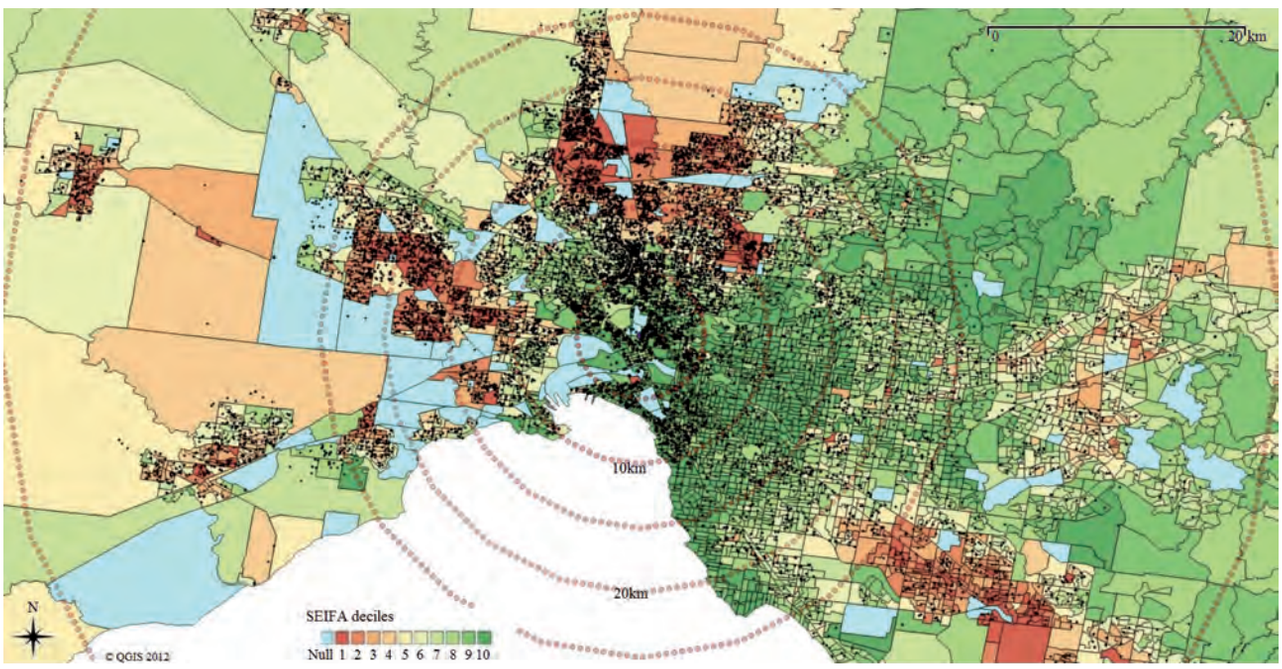

Figure 2a. *Catchment zones for the Melbourne Royal Dental Hospital emergency dental service in 2006 with triage events (black dots) and catchment zones (circles at 5km, 10km, 15km, 20km, 25km and 50km from the RMDH) related to the socioeconomic status (SEIFA values) of the census districts*

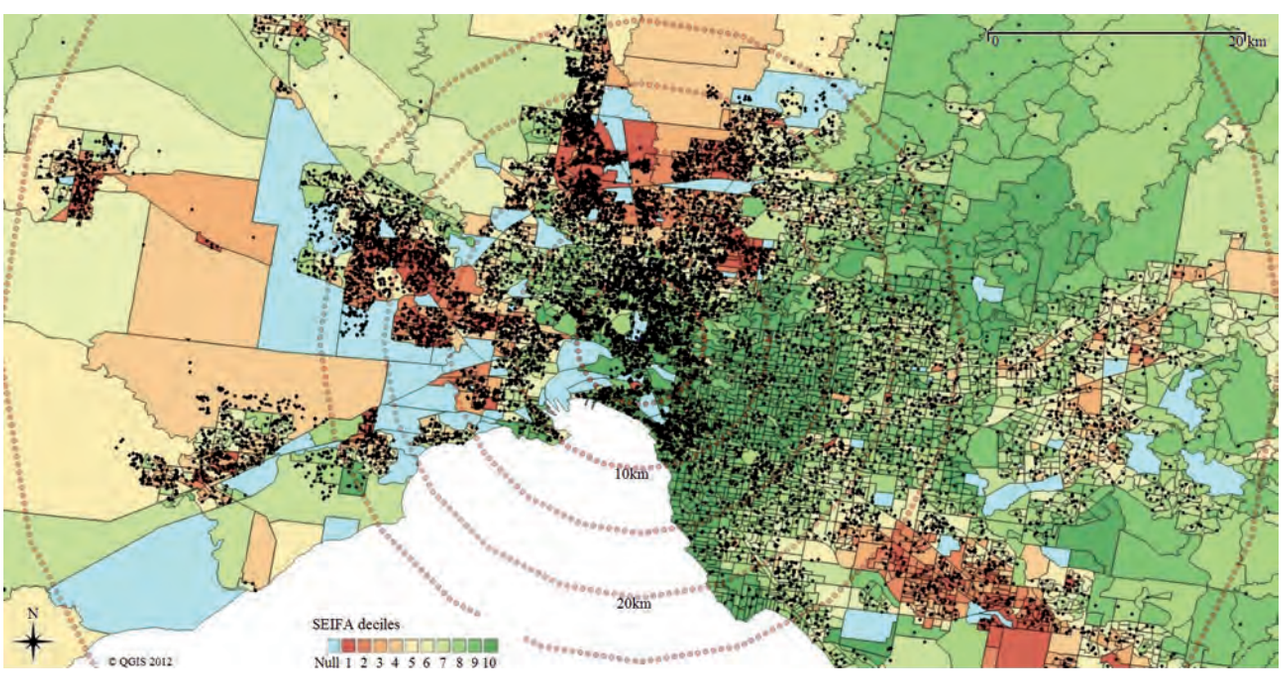

Figure 2b. *Catchment zones for the Melbourne Royal Dental Hospital emergency dental service in 2010 with events (black dots) and catchment zones (circles at 5km, 10km, 15km, 20km, 25km and 50km from the RMDH) related to the socioeconomic status (SEIFA values) of the census districts*

Table 1. Cumulative proportion of emergency events compared by socioeconomic status of the area (SEIFA) and their distance from home to the dental service.

	2006, Emergency events			*2010, Emergency events*		
Distance in km	*SEIFA 1-3, % n=4,168*	*SEIFA 1-5, % n=6,495*	*All 2006, % n=12,186*	*SEIFA 1-3, % n=4,515*	*SEIFA 1-5, % n=7,103*	*All 2010, % n=13,393*
5	9	7	14	8	6	12
10	18	22	35	15	17	29
15	51	49	55	45	40	46
20	74	70	72	66	59	62
25	83	81	82	77	72	75
50	95	95	95	93	93	95

Table 2. Rate of triage events (per 1000 head of population) per socioeconomic status compared to the distance to the dental hospital.

	2006, Patients per 1000 population			*2010, Patients per 1000 population*		
Distance in km	*SEIFA 1 -3*	*SEIFA 1-5*	*All SEIFA*	*SEIFA 1 -3*	*SEIFA 1-5*	*All SEIFA*
5	25	22	8	25	20	7
10	14	11	7	13	10	6
15	11	10	6	11	9	5
20	10	9	5	10	8	5
25	9	8	5	9	8	5
50	6	5	4	7	6	4

third most deprived areas (SEIFA 1 to 3) accounted for 34% of the total number of patients and tend to live more than 15km away from the RDHM. When adjusted to the population of each socioeconomic stratum, it becomes clear that patients from areas with the same socioeconomic status living more than 10km away from the hospital had poorer access to dental emergency treatment (Table 2). The rate of patients (per 1,000 population) within 5km from the hospital was more than double of that within 15km. A best-fit function curve was calculated for the 2006 population adjusted data (noting that the 2010 data were not significantly different). These curves of best fit (for both years) were found to have an R^2 greater than 0.95 for both the poorest 30% of the population and the poorest 50% of the population (Figure 3).

In 2006, there were 2,180 re-attendees compared to 2,205 in 2010. These numbers account for more than 16% of the emergency patients treated every year. About 10% of patients re-attended within 14 days in 2006 and 12% in 2010, accounting for 52% (1,147) of the total duplicates in 2006 and 72% (1,576) in 2010.

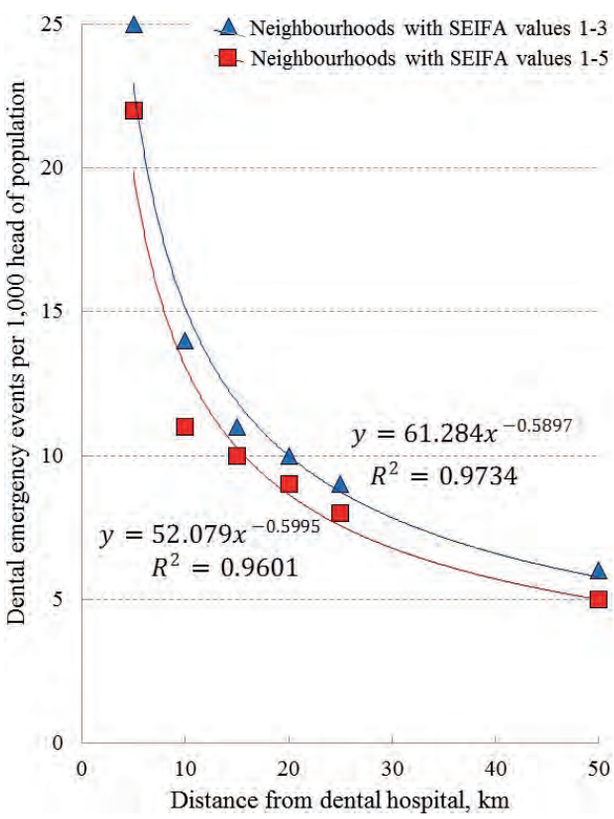

Figure 3. *Best-fit curves (power function), where x is the distance to the dental hospital and y the rate of dental emergency events per 1000 head of population, for (blue triangles) neighbourhoods of SEIFA values 1-3 and (red squares) those of SEIFA values 1-5*

Discussion

Dental disease is strongly linked to socio-economic factors, the more disadvantaged suffering greater burdens of disease (Sanders *et al.*, 2006; Watt, 2007; Watt and Sheiham, 1999). The RDHM is located in the city centre, where most of the population are classified as wealthy (least deprived). The purpose of a public dental hospital is to primarily provide care to the socio-economically

disadvantaged population. Our results indicated however that some 30% of the emergency patients had to travel 20km or more to get to the hospital. It should be noted that as SEIFA values reflect the average socioeconomic status of the census districts (each about 200 households) this does not mean that all the population in that area have the same profile.

An argument can be mounted that a highly mixed community (where wealthy and poor live side-by-side) could account for the lower level of deprivation for patients travelling smaller distances to the centre. Moreover, the RDHM also operates as a tertiary teaching facility and is on the same site as two universities, hence its central location. Additionally, the historical nature of the hospital (some 100 years) would also influence the distribution of patients from the older (more geographically central populations) remaining patients of the hospital despite the changing nature of the community economics around them. Finally, the results reflect a whole population based analysis and potential effects of variations in population demographics across different suburbs impact on emergency care demand.

The key finding of this study was the overall size of the RDHM catchment zone. Catchment zones have previously been defined as the area where 95% of the patients live (McGuire *et al.*, 2011). In the present study, 95% of the patients were living within 50km of the hospital and only 30% of the patients lived less than 10km away from the hospital. The distance from home to the hospital increased slightly from 2006 to 2010 but the differences were not significant providing a relatively stable catchment over time. This catchment zone is thus surprisingly large for a metropolitan area. A previous study focusing on access to dental care of outer Melbourne residents found that, on average, 75% of the patients of the dental clinics studied were living within 10km of the clinic's location. However, this reflected an asymmetric arrangement of patient distribution around each clinic, and appeared to be driven by differences in the distribution of socio-economics of populations, transport and other access factors (McGuire *et al*., 2011).

It was clear that the RDHM's extensive catchment zone overlapped with the much smaller community clinics' zones. In 2005, the annual number of dental emergencies in the state of Victoria, Australia, was estimated in approximately 150,000 (McGuire *et al.*, 2008). The researchers also reported that 80% of the episodes occurred in Melbourne's metropolitan area. Taking into consideration the annual load of 22,710 emergency episodes triaged at the RMDH in 2006, we can assume that the just under 20% of the patients seeking emergency care in the metropolitan area presented at the RMDH. There definitely are social and other factors beyond geography that are influencing a patient's choice of service. Further social studies will be needed to determine the drivers of choice.

Lewis *et al.* (1997) reported that dental hospital patients in Melbourne faced more ecological and organisational obstacles for care than community health centre patients, and pointed to the advantages of *'putting dental services close to the community they serve'*. Despite this, our study showed the opposite, with a large number of patients (living close to community centre dental clinics) attending the inner city hospital for emergency dental care. The reasons for such behaviour were not explored by the present study but may be related to the clinics opening hours, patients' work place, public transport options, patients' preference and the RDHM being recognised as the referral site for emergency dental care for community clinics facing a demand greater than their capacity to serve.

In this study, as in previous ones, straight-line distance to the RDHM has been used as a proxy measure of access. As discussed by Phibbs and Luft (1995) the correlation between travel time and straight-line distance is high in most of the cases, though less well correlated for shorter distances and in dense urban areas with high traffic congestion and reliance on surface roads. Although inner Melbourne has been shown to have a good public transport network (Currie, 2010) the Victoria Transport Department (2009) reported that more than 75% of all trips in Melbourne were made by car, with public transport accounting for only 9%. Moreover, most public transport trips are used during peak times and for work reasons. Given this, the influence of transport options in the choice of emergency dental service needs to be better explored. Further studies should look not only at costs but availability of public transport as a barrier to accessing dental care.

Another interesting finding was that more than 16% of the patients returned for emergency care within the same calendar year of the first consultation. The existence of frequent and typical users of emergency dental care as their main treatment option is well reported in the literature and usually related to poor access to dental treatment (Australian Institute of Health and Welfare, 2003; Okunseri *et al.*, 2011), low socioeconomic status (Australian Institute of Health and Welfare, 2003; Sanders *et al*., 2006) and dental anxiety (Thomson *et al.*, 1996; Armfield *et al.*, 2007). Despite the fact that half of the re-attendees requested another emergency visit within less than 14 days of the first one (a 10% failure rate for the emergency treatment), there is room to improve access to treatment for those that seem to be receiving care only in an reactive emergency-driven approach.

Finally, the importance of geographical mapping in health is not new and the classic example of Dr John Snow (1855) investigating a cholera outbreak in 1854, illustrates this point. GIS's ability to not just map, but also analyse the diverse factors that influence health care accessibility, facilitates understanding and planning of health care provision. The functions presented in Figure 3 are an example of the outcomes that can be expected with such analysis (McGuire *et al.*, 2011). These curves allow for prediction of the rate of dental emergency attendances at a central hospital in a given population per year given the socioeconomic status and distance from the neighbourhood to the dental hospital is known. These may be useful tools for planning services in other cities. Understanding the interaction of such factors is essential in decision making for health workforces and locations of hospitals and clinics.

Conclusion

The RDHM with its central location had a surprisingly large catchment zone (stretching to near 50km) overlapping the areas served by other community based public dental clinics. Factors other than geographic closeness clearly play a role in the clinic that people attend for emergency dental treatment and these factors are significant sustained influences on the location of demand for emergency dental care. Further studies are required to elucidate such factors.

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