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Identifying and prioritising areas of child dental service need: a GIS-based approach

A.T. Alsharif[1], E. Kruger[2] and M. Tennant[2]

[1]*The University of Western Australia, Australia;* [2]*International Research Collaborative, Oral Health and Equity, The University of Western Australia, Australia*

Aim: To identify and prioritise areas of high need for dental services among the child population in metropolitan Western Australia. ***Design:*** All children hospitalised due to an oral-condition from 2000 to 2009, at metropolitan areas of Perth were included in the analysis of a 10-year data set. QGIS tools mapped the residential location of each child and socioeconomic data in relation to existing services (School Dental Service clinics). ***Results:*** The tables and maps provide a clear indication of specific geographical areas, where no services are located, but where high hospital-admission rates are occurring, especially among school-age children. The least-disadvantaged areas and areas of high rates of school-age child hospital-admissions were more likely to be within 2km of the clinics than not. More of high-risk-areas (socio-economically deprived areas combined with high oral-related hospital admissions rates), were found within 2km of the clinics than elsewhere. ***Conclusion:*** The application of GIS methodology has identified a community's current service access needs, and assisted evidence based decision making for planning and implementing changes to increase access based on risk**.**

Key words: *Geographic Information System, hospital admissions, child oral health, Australia*

Introduction

With the substantial reduction in dental decay prevalence in child populations there is an ongoing need for the systems that underpin care for this group to evolve to meet changing oral health profiles. Consistent with the greater exposure of many societies to fluoride, dental decay in children has diminished dramatically. In most developed countries caries prevalence hovers around 50% of the population, and severity as measured by the DMFT index at age 12 years, is below two (Petersen, 2003). Caries experience in Australia is consistent with these global measures (Mejia *et al*., 2012). Several countries have, for many years, operated School Dental Services (SDS), as a universal service model to provide primary dental care to the child population. These services have adapted to falling burdens of dental disease by, for example, means testing, integration with adult services and, in rare cases, cessation or outsourcing to private dental providers. With most of the disease burden now resting with a small minority of children, targeting of dental services to those in greatest need becomes important for effective services. Results of our previous studies indicated that Indigenous status, absence of private insurance, low socioeconomic status and rural living are the most common risk indicators of decreased receipt of preventive service or increased perceived unmet need (Alsharif *et al.,* 2014a;b; 2015). In addition, it is well known that previous history of dental caries is the best indicator of higher future risk. In this study, we used geographic information systems (GIS) methods to identify areas of need for primary dental services for children. GIS is a computational approach to health planning using geo-referenced data (Aronoff, 1993).

The aim of this study was to identify and prioritise areas of high need for dental services among the child population in metropolitan Western Australia using the oral health related hospitalisation data of all children over a ten year period.

Material and Methods

Ethics approval to conduct the study was granted by the Ethics Committee of the University of Western Australia RA/4/1/5502.

To identify any possible gaps in primary dental service provision to children, data from metropolitan Western Australia (WA) were used. WA occupies the western third of the Australian continent; comprising an area of about 2.5 million sq.km with a population of about half a million aged under 15 years (ABS, 2014). Of those, 19% live in the capital city of Perth region (ABS, 2011a). Perth was used for this study as 73% of all hospital admissions for children under age 15 occurred in the metropolitan area, and existing SDS clinics are located predominantly in that area. The existing SDS in WA is a universal coverage model, providing free primary dental care to all school registered children who choose to enrol in the service. Despite being a universally applied system however, it reaches a under 30% of children (GWA DHS, 2008a). Some parents who choose to not enrol their children can access private dental services, but this is not an affordable or accessible option for many. Since 2000, SDS coverage has been declining rapidly, and more children are hospitalised for preventable oral related conditions (Spencer, 2012). Against this backdrop it is important that reliable methods are used to determine the distribution of demand for SDS clinics, to inform policy development and service planning.

Correspondence to: Estie Kruger, International Research Collaborative- Oral Health and Equity, The University of Western Australia, Nedlands, Western Australia 6009, Australia. Email: estie.kruger@uwa.edu.au

Hospitalisation data were analysed for every 0-14-year old, diagnosed and accordingly admitted to hospital in WA for an oral health condition, as classified by the International Classification of Disease – Tenth Australian Modification (ICD-10AM) (CDHAC, 1998). These data were obtained from the WA Hospital Morbidity Dataset (HMDS) for 10 financial years, from 1999/00 to 2008/09. Primary place of residence at the time of hospitalisation were also analysed, using Statistical Local Areas (SLAs) - 37 SLAs cover WA without gaps or overlaps (ABS, 2012a), and their boundary files were obtained from the (ABS) website (ABS, 2011b). Age Standardised Rates (ASR) of child hospital admissions per SLA were calculated using the Health Statistics Calculator developed by the Health Department of Western Australia and population data based on ABS census data. Based on these admission rates per SLA, the entire child population was categorised into five quintiles, separately for each age group.

Admission data for each child was available at SLA level, but for higher accuracy and precision analysis, a smaller area-based analysis was needed, and therefore census Collection Districts (CDs) were used. A CD is much smaller than an SLA, and is a quasi-measure of density of residents (based on an area that a single census officer can collect data from). Census collection districts and the geographic boundaries of each CD were obtained from the ABS webpage (2011b). The Perth metropolitan area covers 2,840 CDs, 65% of the WA's CDs, with more than 270,000 under 14-year-olds. Hospitalisation data across each of the 37 WA SLAs were distributed by age groups (0-4, 5-9 and 10-14 years). For each age group, the rates of child hospitalisations was calculated for each SLA then this SLA rate was applied to each of the SLA's CDs.

The number of under-15-year-olds for each CD were obtained from the ABS (2006) census data (ABS, 2013b).

For socioeconomic data, each CD has a Socio-Economic Indexes of Area score (SEIFA 2006) assigned by the ABS, based on socio-economic indicators of the CD's population (ABS, 2013a). SEIFA is a nationally accepted coding system ranking areas in Australia according to relative socio-economic advantage based on five-yearly census data (ABS, 2013b). These rankings were dichotomised into most disadvantaged areas (Poorest, SEIFA deciles 1 to 5) and least disadvantaged areas (Wealthiest, SEIFA deciles 6 to 10).

The addresses of all fixed SDS clinics were obtained from the Department of Health (ABS, 2011b) and geocoded, i.e. changed into map coordinates and located on a map. The populations of children who lived within 2km of each SDS clinic were identified.

Geographic information systems (GIS) in this study were used as a technique for integrating hospitalisation data related to dental disease with known risk indicators (e.g. socioeconomics), to identify and prioritise geographic areas of high need for a dental service. The approach while tested on this one city was designed to be universally applicable. The resultant maps indicated where SDS clinics were located, as well as the following attributes of the child population both within and outside of a 2km zone around it: population density, age-specific hospital admission rates and an indication of area socio-economic disadvantage.

All mapping and geocoding of data used QGIS v.2.6 (Boston, USA), analyses used SPSS 21 for Windows and data were tabulated in Excel 2007.

Results

From 2000 to 2009, 31,910 metropolitan Perth children aged from 0-14 years were hospital admissions for oral-related conditions. All 77 fixed SDS clinics were included, with a ratio of 2,414 school aged child population per clinic.

The distributions of hospital admissions rates by both socio-economic status and location inside or outside 2km of a clinic are presented in Tables 1, 2 and 3. More children (68%) lived within 2km of existing SDS clinics than further away. Of all children living within 2km of a clinic, 18% of 0-4 year olds come from areas with higher (i.e. high or very high) admission rates and low socio-economic scores (poorest urban areas) (Table 1). In addition, 11% and 5% of 5-9 and 10-14 year-olds, respectively, were living in the poorest areas with higher admission rates (Table 2 and 3).

About a third of children live outside the 2km zones, 6% of them come from the poorest and higher admission rates urban areas. Meanwhile, 41% of all the children are from the wealthiest areas with higher hospitalisation rates and lived predominantly more than 2km from a clinic (Tables 1-3).

Table 1. Zero to four years old child population distribution by hospital admission rates and socioeconomic status inside/outside the 2km Zone of existing SDS clinics

Admission rates[1]	*Inside the 2km zones*						*Outside the 2km zones*					
	Poorest areas		*Wealthiest areas*		*Overall*		*Poorest areas*		*Wealthiest areas*		*Overall*	
Very low	3,964	(7%)	7,791	(13%)	11,758	(20%)	1,153	(4%)	5,349	(20%)	6,502	(24%)
Low	4,656	(8%)	6,181	(10%)	10,837	(18%)	1,340	(5%)	4,525	(17%)	5,871	(22%)
Moderate	6,355	(11%)	6,947	(12%)	13,302	(23%)	967	(4%)	3,525	(13%)	4,492	(17%)
High	5,000	(8%)	7,170	(12%)	12,170	(20%)	1,077	(4%)	3,073	(11%)	4,150	(15%)
Very high	5,431	(9%)	5,528	(9%)	10,962	(18%)	1,950	(7%)	4,103	(15%)	6,080	(22%)
All rates	25,406	(43%)	33,617	(57%)	59,029	(100%)	6,487	(24%)	20,575	(76%)	27,097	(100%)

[1]All admission rates per 100,000 population: Very low=0-1141, Low=1142-1183, Moderate=1184-1209, High=1210-1299, Very high≥1300)

Table 2. Five to nine years old child population distribution by hospital admission rates and socioeconomic status inside/outside the 2km Zone of existing SDS clinics

Admission rates[1]	*Inside the 2km zones*			*Outside the 2km zones*		
	Poorest areas	*Wealthiest areas*	*Overall*	*Poorest areas*	*Wealthiest areas*	*Overall*
Very low	8,046 (13%)	5,606 (9%)	13,652 (22%)	2,904 (10%)	3,059 (11%)	59,729 (21%)
Low	5,356 (9%)	7,161 (12%)	12,520 (21%)	1,229 (4%)	3,203 (11%)	4,438 (15%)
Moderate	5,287 (9%)	7,255 (12%)	12,545 (21%)	1,301 (5%)	3,226 (11%)	4,546 (16%)
High	4,567 (7%)	6,499 (11%)	11,066 (19%)	1,058 (4%)	5,240 (18%)	6,298 (22%)
Very high	1,884 (3%)	9,256 (15%)	11,140 (18%)	18 (0.1%)	7,115 (25%)	7,133 (25%)
All rates	25,140 (41%)	35,777 (59%)	60,923 (100%)	6,510 (100%)	21,843 (100%)	28,387 (100%)

[1]All admission rates per 100,000 population: Very low=0-1041, Low=1042-1139, Moderate=1140-1209, High=1210-1391, Very high≥1392)

Table 3. Ten to fourteen year old child population distribution based on hospital admission rates and socioeconomic status inside/outside the 2km Zone of existing SDS clinics

Admission rates[1]	*Inside the 2km zones*			*Outside the 2km zones*		
	Poorest areas	*Wealthiest areas*	*Overall*	*Poorest areas*	*Wealthiest areas*	*Overall*
Very low	8,691 (13%)	5,356 (8%)	14,053 (21%)	2,186 (7%)	1,793 (6%)	3,985 (13%)
Low	6,362 (10%)	9,564 (14%)	15,929 (24%)	1,605 (5%)	4,124 (13%)	5,806 (18%)
Moderate	7,964 (12%)	9,103 (14%)	17,067 (26%)	1,708 (5%)	2,813 (9%)	4,534 (14%)
High	2,346 (4%)	7,263 (11%)	9,609 (15%)	1,117 (4%)	8,130 (26%)	9,247 (30%)
Very high	580 (1%)	8,042 (12%)	8,686 (13%)	43 (0.1%)	7,647 (24%)	7,690 (24%)
All rates	25,943 (40%)	39,328 (60%)	65,344 (100%)	6,659 (21%)	24,507 (78%)	31,262 (100%)

[1]All admission rates per 100,000 population: Very low=0-652, Low=653-773, Moderate=774-817, High=818-980, Very high≥981)

In this analysis, the term 'highest risk areas' refers to CDs with the poorest areas and having high oral related hospital admissions rates; 'lowest risk areas' being the wealthiest with the lowest admission rates. Note that admissions were based on children's addresses at the time of admission. The location of clinics were considered as a potential barrier to children's hospital admissions through access to early diagnosis and treatment.

Large geographical variations of high risk areas in relation to age, either outside of, or inside the 2km zone of existing SDS clinics, were observed (Figures 1 and 2). More high risk areas were observed among pre-school aged children, regardless of their location in relation to the clinics. High risk areas for children aged under 5 years were more likely to be within, rather than outside of a 2km radius of a clinic. There were also more high risk areas within, rather than outside 2km of clinics (Figures 1 and 2) for children older than 5 years. Most high risk areas were in the peripheral areas of this particular metropolitan region.

Figures 3 and 4 compared the high oral related admission rates of children living in the wealthiest areas, outside and inside the 2km zone of existing SDS clinics and reveal large geographical variation. For the wealthiest areas, those with high admission rates of school-age children were more likely to be within a 2 km of a clinic than further away. However, many areas at risk of high (school-age children) hospitalisation rates were found more than 2km from a clinic, where no SDS service is available. Most wealthier areas with high pre-school child hospital admission rates, were concentrated in peripheral areas of this metropolitan region.

When comparing children of different age groups, from poorest/wealthiest areas, where high risk of hospitalisations occur, differences were observed (Figures 1-4). Most areas with high risk pre-school admission rates, were from the poorest areas. In contract, most of high risk school-age hospital admissions areas, were from the wealthiest areas, with a significant number being in areas with worse SDS coverage.

Discussion

While there has been a significant reduction in tooth decay levels in children over the last generation in Australia as in other developed economies, marked inequalities in oral health still exist. Results of our earlier work on the incidence of oral related hospitalisations among the child population of Western Australia were previously published (Alsharif *et al.,* 2014a). It has been determined that the total Diagnosis Related group (DRG) cost of these admissions was $92 million, with an estimated additional $138 million as indirect cost (Alsharif *et al.*, 2015). While hospitals are a vital component of any health system, the Australian dental health care system is searching for ways to increase SDS coverage and reduce costs of hospitalisations. One clear strategy is to increase the access to and utilisation of those universal primary care and preventive services.

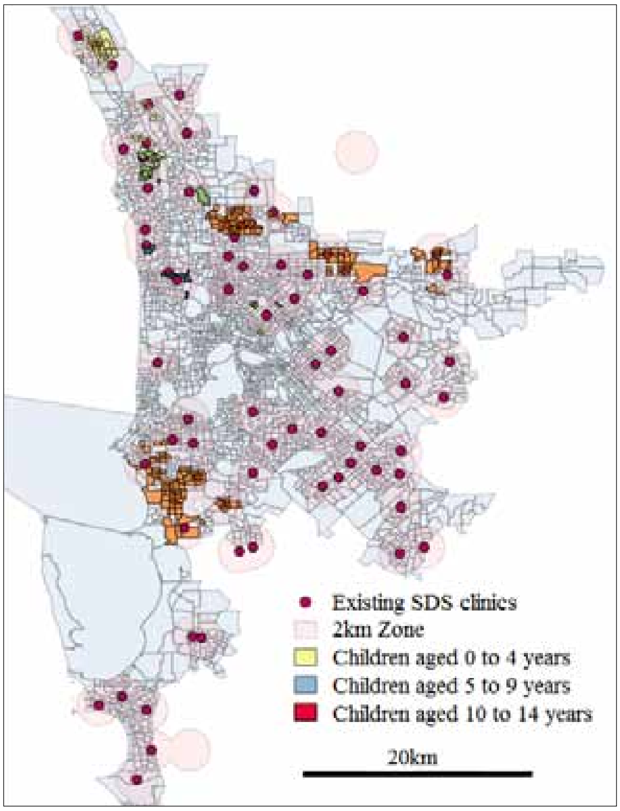

Figure 1. *High age-adjusted oral related admission rates of children living in low socioeconomic areas (SEIFA<6) inside 2km zones of existing School Dental Service clinics in Perth*

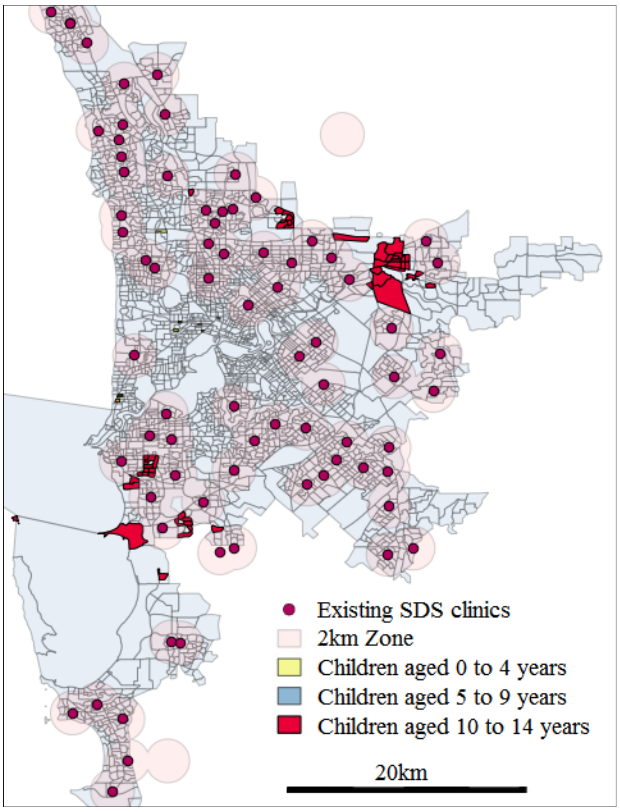

Figure 2. *High age-adjusted oral related admission rates of children living in low socioeconomic areas (SEIFA<6) outside 2km zones of existing School Dental Service clinics in Perth*

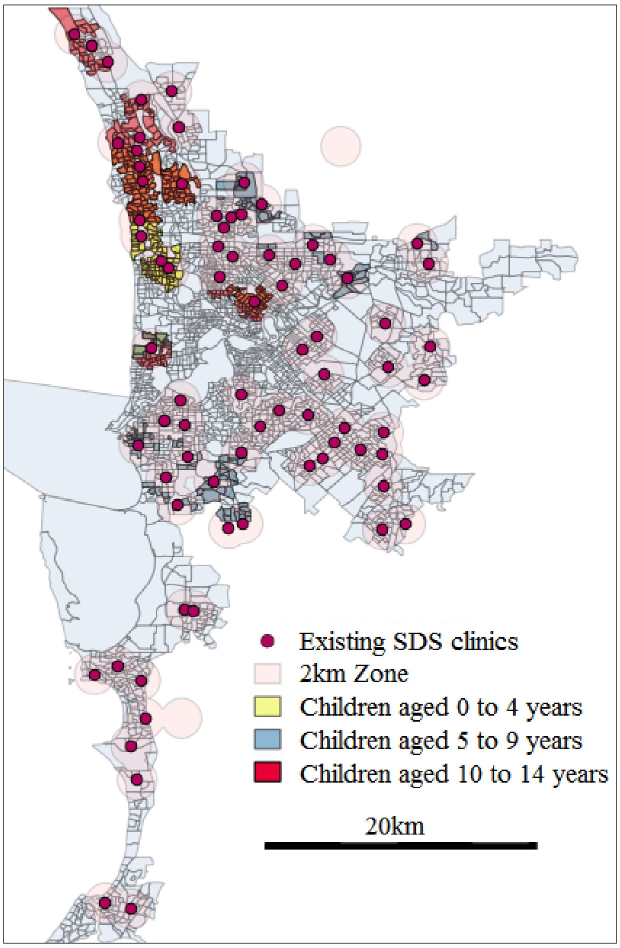

Figure 3. *High age-adjusted oral related admission rates of children living in high socioeconomic areas (SEIFA>5) inside 2km zones of existing School Dental Service clinics in Perth*

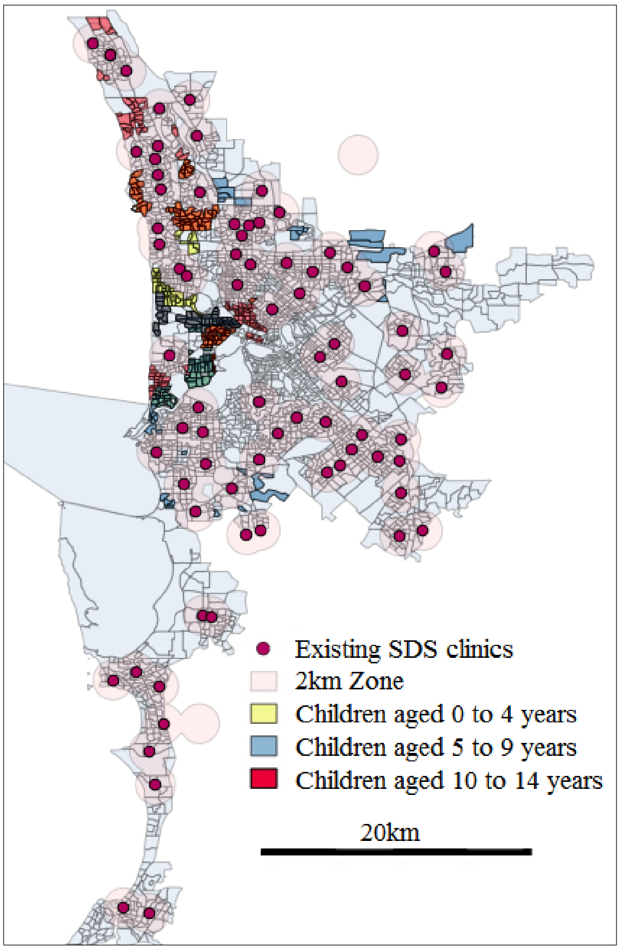

Figure 4. *High age-adjusted oral related admission rates of children living in high socioeconomic areas (SEIFA>5) outside 2km zones of existing School Dental Service clinics in Perth*

In the present study, integrated data from hospital admissions, socio-economic population-based indicators, and service locations, were used to form a cohesive risk-based geographic output to support the spatial configuration of future service planning. The study demonstrates an application of GIS to population-based oral health planning.

The findings reflect the oral health profile disparities of a metropolitan population. Preventable oral hospitalisations have been proposed as a key marker of poor health plan performance (AIHW, 2014). Currently, SDSs are the main public child dental program in Australia, providing dental checkups, emergency and basic treatment, but cover only limited care for enrolled school children, particularly those within disadvantaged families (NSW OHA, 2010). Treatment outside the scope of the SDS is referred to other providers and any costs are the responsibility of the parent or guardian (GWA DHS, 2008b). Many studies confirmed that lower use of preventive health services, delay seeking primary care and higher levels of oral diseases are observed among children living in low socioeconomic areas, these untreated symptoms get more severe and admission for complex treatment may be inevitable (ABS, 2010). However, admission rates do not reflect the actual burden of the disease among disadvantaged groups possibly due to economic constraints and reduced mobility.

On the other hand, a different admission pattern was evident among children from high SES areas. These children were more likely to be admitted for oral conditions than those living in more deprived areas. Based on our previous study using the same data set, 76% of children in wealthy areas have private dental health insurance (compared to only 24% of those in poor areas) which might indicate that insurance enabled improved access to dental care and led to greater demand for hospital-based care once access had been obtained (Alsharif *et al.*, 2014b; Bagramian *et al.*, 2009).

This can be confirmed by the findings in Figures 3 and 4, where children from wealthy areas are more likely to be admitted for oral related conditions than children living in poor areas. Nevertheless, it is obvious from our previous analysis that insured, wealthy children are more likely to be admitted for less invasive treatment than their most deprived counterparts (who were probably more likely to receive invasive treatment), (Alsharif *et al.*, 2014a;b) despite individuals from poor backgrounds carrying a higher burden of oral disease (AIHW, 2011). In general, it is evident that people from the most deprived areas were less likely to have taken preventive health actions such as dental screening, or having their teeth cleaned (ABS, 1999). Our study findings suggested that variations in SES may lead to variations in utilising complex health service based on need. This may contribute to widening oral health inequalities among Australians, with more low-SES children requiring admission for more invasive treatment which has a much greater public expense than if they had been provided dental treatment when the symptoms first occurred.

The results and maps provide a clear indication of specific geographical areas (in this city) where no local service is provided, but where high hospital admission rates occur especially among school-age children.

Therefore, our findings provide valuable insights to the extent of child oral health admissions in relation to access to existing services and deprivation mapped in detail across the city. These findings provide a methodological approach that can be applied, not just locally, but elsewhere to assist in planning resource allocation, prioritising services and targeting of interventions.

Conclusion

This study has applied GIS methodology to identify a community's current service access needs, and informed evidence based decision making for planning and implementing changes to increase access based on risk. The methods developed in this framework can be adopted by other communities to identify a set of target areas with vulnerable populations and subsequently to monitor the effectiveness of remedial interventions. This model may be particularly well suited for planning and prioritising future health services in other urban communities, based on population projections and disease models of the current population.

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