

# The geographic distribution of podiatrists in Perth, Western Australia

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This study examined the spatial accessibility of podiatry services to aged people living in the Greater Perth area, and access to these services for people from different socioeconomic groups, using geographic information systems (GIS). All persons older than 65 years (n=216 062) were included in the study and divided into two subgroups (retirees and elders) by age. Census data, bus stops (high and medium accessible stops) and train station data were integrated with GIS to analyse population spatial accessibility. The study found that most of the aged population resided within 2 kilometers of podiatry clinics, and the podiatry services are well distributed. In terms of access to buses, around three-fifths of aged people lived within 1 kilometer of high-access bus stops, and more than four-fifths of this population resided within 1 kilometer of medium-access bus stops. The distribution of podiatrists among people from different socioeconomic areas showed the density of podiatry services was higher in more affluent areas, therefore, the Inverse Care Law is evident in access to podiatry services in the Greater Perth region.

**Keywords:** aged population, podiatry services, spatial accessibility, density, buses, and trains.

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Western Australia is geographically the largest state in Australia, with a total area of more than 2.5 million square kms (a third of the total area of Australia) and a population (in 2011) of 2.2 million people [1]. Of this population 1.7 million people (77%) are living in the capital city, Perth. In recent years, the population growth was double that of other cities in Australia [2]. A little over 200,000 residents of Perth are over the age of 65 years, and it is forecasted that the age structure in Perth will change consistent with the global trend in developed countries. The predictions are that there will be a decrease in the working-age population from 89% to 64%, and an increase in retirement age proportion of people to 66% by 2026 [3]. Clearly this shift in population demographics will require substantial and rapid planning for health and welfare services over the next decade. Australia is thus

facing the classic developed country issues of an aging population whilst being relatively wealthy and it being substantially a healthy population [4]. Many health services are available, both public and private, but the use of these services depend on geographic accessibility. Australian cities are not densely packed cities and the reliance on vehicle transport is high. Geographical accessibility to healthcare services is one of the fundamental components of healthcare [5]. The ageing of the Australian population has already, and will continue to drive strong growth in podiatry services (<https://www.aihw.gov.au/>). This study examined the spatial accessibility of podiatry services to the population of the Australian metropolis of Perth, using a geographic information system (GIS)

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approach, with a focus on the retired and elders, and taking transport options into consideration.

## Methods

As only openly accessible and freely available data were used in this study, no ethics approval was required.

**Podiatry practice locations:** The podiatry directory from November 2015 was used to determine public service locations [7]. This directory updates every year and shares information about the Department of Health (DOH) and publicly funded podiatry services available in Western Australia. The private services were gathered from the yellow pages and addresses were confirmed with Google maps.

**Population data:** All population data (including age distribution) were obtained from the 2011 Census. The data frameset for this study include all people living within 50 km of the Central Post Office in Perth. Population groups were categorized according to age, with a focus on retirees and elders. Retirees included all people older than 65 years old, and elders include all those older than 85 years.

**Train systems in Perth:** Perth, like the other Australian capital cities, has a comprehensive local train network. There are four Perth train lines, radiating out from the main Perth city train station [8]. All the train stations were included in this study. The geographic data for train stations is available on the [TransPerth](http://www.transperth.wa.gov.au) website (<http://www.transperth.wa.gov.au>).

**Bus system in Perth:** Two bus terminals are located in the Perth metropolis: the Wellington street bus station and the City Bus port. The Wellington street bus station is approximately 200m from the main city centre train station, and services the northern suburbs. The geographic data for bus stations were available from the [Transperth](http://www.transperth.wa.gov.au) website (<http://www.transperth.wa.gov.au>). High and medium frequency bus stops were considered separately. The “high” frequency stops were where busses stop at least 48 times per day (every 15 minutes) and “medium” had a lower frequency of less than 48 busses per day.

**Population data and socioeconomics:** Census data from the most recently available (and geo-coded)

census (2011) were used for the study (<http://www.abs.gov.au>). A total of 1976 Perth SA1's (the smallest geographic area the census data is divided into) had centroids within 50 km of the central post office. Consistent with previous studies this was deemed to be the Greater Perth region and used in the study as the definition of Perth.

The socioeconomic status of the population was analyzed using the Socioeconomic Index for Areas (SEIFA). The Australian Bureau of Statistics (ABS) uses SEIFA, a composite index of relative socioeconomic disadvantage, and determined from indicators collected by the ABS within each set of census data. In this research the deciles of SEIFA will be dichotomized, with deciles 1-5 classified as low socioeconomic, and the deciles 6-10 classified as high socioeconomic.

**Data integration and analysis:** All data were integrated using QGIS (version 10.0), and analyses were completed using Excel (version 2010; Microsoft Corporation, Seattle, WA, USA). QGIS software was used to formulate an integrated buffer zone around each podiatry service location, train and bus stations. Two optional zone radii were applied; zone A was 1 km wide, and zone B was within a 2 km radius from a podiatry service location.

## Results

**The aged population and podiatry locations:** The aged population (65 years and over) living in the Greater Perth area was 216,062, of which 187,925 were retired (65-84 years old) and the others, 28 137, were elders (over 85 years old). A total of 104,928 adults (retiree and elderly) lived within zone A (within 1km of a podiatry service), whilst 73,875 adults lived within zone B (between 1 km and 2 km of a podiatry clinic). These, respectively, constituted 48.6% and 34.2% of the total retirees and elders' population of Greater Perth. For retirees, 89,21 (47.6%) lived within zone A, and 64,118 (34.1%) lived within zone B. For the elders, 15,407 (54.7%) and 9,757 (34.7%), respectively, resided in zone A and B (Table 1).

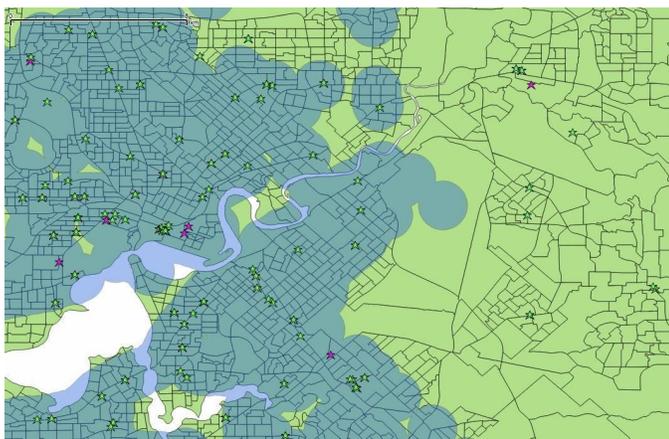
**The aged population and bus stops (high and medium stops):** In this study high and medium bus stops have also been investigated (the stations with high and medium numbers of times that the bus stops, or frequency of stops).

Adults	Within 1 km (Zone A)	Within 2 km (Zone B)	Outside 2 km	Total
Retirees	89,521 (47.6%)	64,118 (34.1%)	34,286 (18.3%)	187,925 (100)
Elderly	15,407 (54.7%)	9,757 (34.7%)	2,973 (10.6%)	28,137 (100)
Total	104,928 (48.6%)	73,875 (34.2%)	37,259 (17.2%)	216,062 (100)

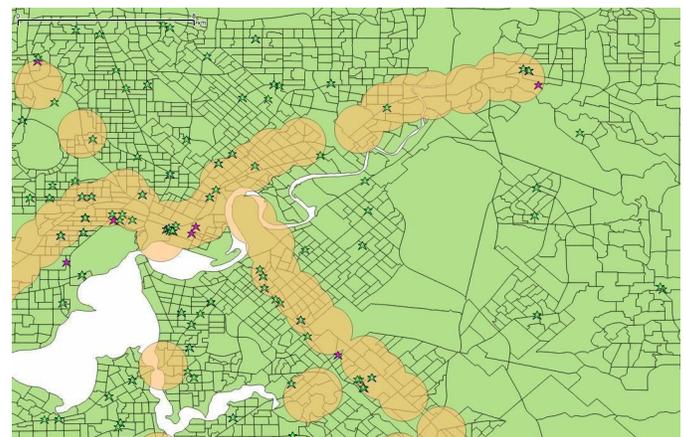
**Table 1** The number and percent of retirees (65-84 years old) and elderly (over 85 years old) living within 1 km, 2 km and outside 2 km of a podiatry service in Greater Perth.

Adult	Within 1km of high bus stops	Within 1km of medium bus stops
Retirees	110,426 (59%)	157,778 (84%)
Elderly	19,059 (68%)	24,681 (88%)
Total	129,485 (60%)	182,459 (84.4%)

**Table 2** The number and per cent of the aging population living within 1 km of high and medium bus stops in Greater Perth.



**Figure 1** Podiatry services locations in the Perth metropolitan area (green stars for private services and the pink for public services), and 1 km buffer zones around high frequency bus stops (blue circles).



**Figure 2** Podiatry services locations in the Perth metropolitan area (green stars for private services and the pink for public services), and 1 km buffer zones around medium frequency bus stops (orange circles).

A total of 129,485 retirees and elderly lived within 1km of high frequency bus stops (Figure 1), and 182 459 adults lived within 1 km of medium frequency bus stops (Figure 2). These, respectively, constituted 60% and 84% of the 216,062 total retirees and elders' population of Greater Perth. For retirees, 110,426 (59%) lived within 1 km of high frequency bus stops, and 157,778 (84%) lived within 1 km of medium frequency bus stops. For the elders, 19,059 (68%) and 24,681 (88%), respectively, lives within 1km of high and medium frequency bus stops (Table 2).

	Within 1km	Within 2km	Outside 2km	Total
Retirees	29,547 (15.7%)	37,762 (20.1%)	120,616 (64.2%)	187,925 (100)
Elderly	5,726 (20.35%)	6,280 (22.3%)	16,131 (57.3%)	28,137 (100)
Total	35,273 (16.3%)	44,042 (20.4%)	136,747 (63.3%)	216,062 (100)

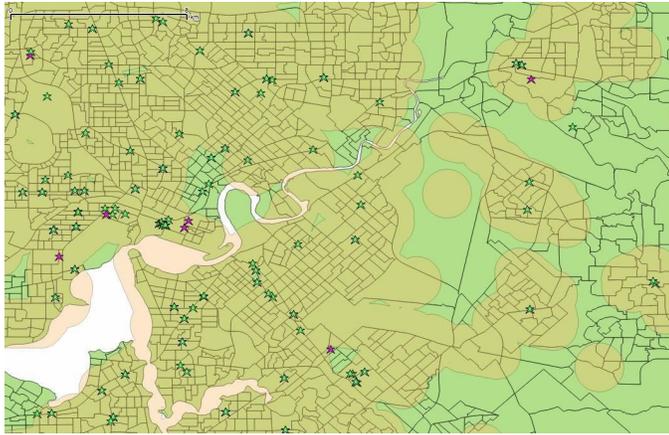
**Table 3** The number of older people living next to 1km of train stations.

The aging population and train stations: This study identified the density of the aging population living next to train stations (Table 3). A total of 35,273 retirees and elders lived within 1km of train stations, and this amounts to around 16% of the aged population in Greater Perth (Figure 3).

Around 20% of this population lived within 2km of train stations and the rest (63%) lived outside 2km of train stations.

Socioeconomics: SEIFA was used to examine the relative socioeconomic status and proximity to podiatry services and public transport, and found lower percentages of the most disadvantaged half of the population (the first five deciles) lived closer to

podiatry services, compare to the least disadvantaged half of the population (Table 4).



**Figure 3** Podiatry services locations in the Perth metropolitan area (green stars for private services and the pink for public services), and 1 km buffer zones around train stations.

	SEIFA deciles									
	1	2	3	4	5	6	7	8	9	10
Aged Population										
Retirees Zone A	4697	6886	6621	7444	8041	7619	8888	11290	12958	15024
Retirees Zone B	3644	4852	6490	6359	6672	6943	6011	6429	7071	9664
Total	8341	11738	13111	13803	14713	14462	14899	17719	20029	24688
Total of five deciles	61706 (28.5%)					91797 (42.5%)				
Elders Zone A	949	1179	1221	1350	1551	1558	1564	1970	2005	2060
Elders Zone B	1259	681	1099	1083	1090	902	866	891	730	1070
Total	2208	1860	2320	2433	2641	2460	2430	2861	2735	3130
Total of five deciles	11462 (5.3%)					13616 (6.3%)				
Retirees-high bus stops 1km	5391	7628	9150	12294	11573	9778	10365	13309	14506	16108
Elders-high bus stops 1km	1498	1328	1811	2107	2180	1738	1823	2259	2068	2164
Total	55160 (%25.5)					74118(%34.3)				
Retirees-medium bus stops 1km	8410	12378	14171	15657	16438	14837	15335	17951	19878	22587
Elders-medium bus stops 1km	2229	1906	2542	2424	2671	2519	2303	2689	2496	2816
Total	78826 (%36.5)					103411 (%48)				
Retirees-1km of train stations	1476	2520	2444	2662	2823	2182	2650	4155	3824	4777
Retirees-2km & 1km train stations	1482	3052	2971	3619	3247	3346	3777	4866	5649	5738
Total	2958	5572	5415	6281	6070	5528	6427	9021	9473	10515
Total of five deciles	26206 (-12.20%)					40964 (-19%)				
Elders-1km of train stations	370	669	338	431	652	485	448	307	678	745
Elders-2km & 1km train stations	281	343	614	571	586	710	620	802	866	887
Total	651	1012	952	1002	1238	1195	1068	1709	1544	1632
Total of five deciles	4855 (-2.20%)					7148 (-3.30%)				

**Table 4** The number and percent of retirees (older than 65 years old) and elderly (older than 85 years old) living within zone A, zone B, high and medium bus stops and 1km and 2km of a train station, divided by Socioeconomic Index for Areas (SEIFA) deciles\* in metropolitan Perth. Note: The percent shows the percentage of total aging population. \* Decile 1=poorest, decile 10 =wealthiest.

**Discussion**

Spatial accessibility to healthcare facilities has been the focus of many studies in Australia, with the distance to facilities being highlighted as a barrier to access and subsequent utilisation of services (10). In total, 82% of retired (48% in zone A and 34.1% in zone B) and 89.4% of elders (55% in zone A and 35% in zone B) lived within 2 km of podiatry clinics, which it is 82.8% of the total aging population in Greater Perth. This information shows that podiatry services

are distributed relatively uniformly among this population (Table 1) and most aged people have access to a podiatrist within a 2 km distance at most. Most of the aging population resided within 1km of high and medium bus stops, and therefore most of the retired and elders can use buses to visit podiatrists (Table 2).

There was a different trend in the distribution of train stations among the retired and elders, compared to proximity of them to bus stops, the train stations were not a suitable selection to access podiatry locations. In total, 36% of the retired population lived within 2km of train stations (15.7% within 1km and 20.1% within 2km) and 43% of elders resided within 2km (20% within 1km and 22% within 2km). In total, 36.7% of the whole aging population resided within 2 km of a train station.

In conclusion, access to podiatry services via train stations, does not seem to be a suitable option (Table 3), because 63% of total aging people resided outside of 2km from a train station. This study also focused on the public transportation accessibility of aged people from different socioeconomic backgrounds. Public transportation is very important to the older population in general, as they depend more on public transportation than young people. Also, older people, (especially after 70 years of age) start to surrender their driving licenses and depend on others to transport them to health facilities (11). They have limitations of using and driving personal vehicles, whilst at the same time experiencing a greater need for health care (12). However although retirees and elders depend on public transport, a lower proportion of them were living in close proximity to train stations.

The relative socioeconomic status and proximity to podiatry clinics, bus stops and train stations have been investigated, and the most disadvantaged of the retired and elders were less likely to live within up to 2 km of podiatry services (zone A and B) compared to wealthier older people. This data shows that the distribution of podiatrists were more likely to be among wealthier people, than people from lower socioeconomic areas. Only 17.4% of the total aged population lived outside of zone B. In terms of accessibility to bus stops (high and medium) within 1km, the wealthier groups had more spatial accessibility to both high and medium bus stops

(34.4% and 48% respectively), while the low income people had less accessibility to bus stops, 25.5% for high and 36.5% for the medium stops. This difference is not too significant. In comparison between poor and wealthy aged people and access to train stations (within 2km) has shown that there were significant differences between these two groups., Only 14.4% of retired and elders from disadvantaged areas were located within 1 and 2 km of train stations (12.2% retired and 2.2% elders). The percentage of the aging population with high socioeconomic status was 22% within up to 2km of train (19% retired and 3.3% elders). This study indicated that the higher percentage of the aging population (63.3%) with different socioeconomic resided outside of 2km of train stations. According to this data, the Inverse Care Law applies to the aged population in the Greater Perth metropolitan area. The definition of this law is “The availability of good medical care tends to vary inversely with the need for it in the population served”(13). On the other hand, public transportation was located closer to wealthier populations. It should be investigated to determine if people from wealthier areas suffer from higher burdens of foot problems or diseases associated with foot health (such as diabetes), than those from poorer areas. It might be that those from more disadvantaged areas are more unaware of feet health, or that the cost and affordability of podiatric care act as a barrier to obtain care.

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