

# Disparities in spatial accessibility to public dental services relative to estimated need for oral health care among refugee populations in Victoria

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## Abstract

**Objectives:** To examine the spatial accessibility to public dental services (PDS) relative to the estimated oral health needs of refugee populations within the state of Victoria, Australia.

**Methods:** The study employed enhanced two-step floating catchment area method to measure spatial accessibility to PDS by driving and public transit modes at statistical area level 2 (SA2). Principal component analysis of select census-derived socioeconomic variables specific to the refugee population was conducted to derive an area-based indicator of refugee oral health needs, also at SA2 level. Individual indices were then developed for each of these components using standardized z-scores. Finally, an integrated need-accessibility index was developed to identify low-accessibility areas associated with high needs.

**Results:** The results show clear contrast in spatial accessibility to PDS for the refugee populations between metropolitan and rural areas as well as between driving and public transit modes. There are critical limitations in accessibility for refugees living in the rural areas and those dependent on public transit mode for travel. Also, there is evident disparity between the estimated oral health needs of refugees in metropolitan and rural areas. Overall, approximately 29% of all SA2s with refugee population are in the 'High' needs category, which comprise 19.8% of the total Victorian refugee population. Integrating accessibility and oral health needs measures revealed that about 30% and 18% of refugee population are identified as under-served, when considering driving and public transit modes respectively.

**Conclusion:** The findings provide implications for researchers and policy makers to address the inequalities in access to PDS among the refugee population in Victoria. The methodology outlined in this study provides a complementary approach in planning oral health service provision in the absence of population level data at a small-area scale on access to dental services or need for oral health care.

## KEYWORDS

dental health services, health services accessibility, health services needs and demand, population oral health, refugees

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## 1 | INTRODUCTION

Access to appropriate dental care is important to promoting and maintaining overall health and well-being of an individual, by providing timely diagnosis and treatment of existing oral diseases, risk assessment and primary prevention.<sup>1</sup> Access to dental care is a multidimensional construct and entails both spatial and aspatial dimensions.<sup>2,3</sup> Studies have shown that geographic barriers, such as distance or travel time to service location, are significant pertaining to access and utilization of dental care.<sup>4-6</sup> Aspatial dimension encompasses a number of demographic, socioeconomic, cultural and oral health need attributes that impact various oral health outcomes and are different for each population subgroup.<sup>7-10</sup> Therefore, within a given geographic area, while spatial access to a dental service provider could be the same for the entire population, aspatial access varies across subgroups based on their aspatial attributes.

Refugees are considered a vulnerable group, as they are at an increased risk of poor oral health. The unequitable burden of oral disease and access to dental care between the refugee and general population is well documented in the global<sup>11</sup> and Australian literature.<sup>12-15</sup> Every year approximately 30% of refugees entering Australia resettle in Victoria; in 2016, there were approximately 69 000 refugees living in the State.<sup>16</sup> Although the Commonwealth of Australia provides all refugees access to universal health care, dental services are not included in this. In Australia, government subsidized dental services or public dental services (PDS) are only provided to select eligible population groups, as stipulated by each of the states. To address the needs of resettled refugees, the state of Victoria extended the eligibility and 'priority access' (where next available appointment is given without placing on waiting list) to PDS for all refugees, at no cost.<sup>17</sup> Despite these measures, a recent audit of Victorian PDS indicated low levels of use of PDS among refugees,<sup>18</sup> highlighting the need to understand the access barriers for this population group.

Literature on factors influencing dental care access among resettled refugees highlights both spatial and aspatial barriers. Refugees in Australia frequently report that challenges to reaching geographically distanced dental services due to lack of private transport, difficulty with understanding the public transport system and/or the costs associated with the travel as barriers to accessing dental care.<sup>19</sup> Aspatial barriers, such as limited English language proficiency and differences in the cultural attitudes between refugees and dental professionals, significantly hindered their ability to navigate through the dental care system.<sup>14,19</sup> In addition, other socioeconomic barriers related to resettlement in the host country, including housing and employment, also negatively impacted their oral health care seeking behaviour.<sup>14,20</sup> It is important therefore that any comprehensive evaluation of refugee access to dental care accounts for both spatial and aspatial factors.

This study assesses the combined spatial and aspatial access to PDS for the refugee population in the state of Victoria. In Victoria, access to dental care demonstrates a strong spatial component because of large area-based differences in the distribution of dental

services, population densities and socioeconomic attributes of the population, across metropolitan and regional, rural and remote areas (herein rural areas).<sup>21,22</sup> This urban-rural divide is particularly consequential with respect to the already vulnerable refugee population.<sup>18,23</sup> Moreover, refugees within Victoria constitute diverse subgroups of individuals with different demographic, cultural and socioeconomic backgrounds. It is within this context that this study is conducted, to examine the spatial distribution of PDS and the extent to which the provision of PDS is equitable relative to the aspatial barriers of the Victorian refugee population. The specific objectives of this study are to: (1) model spatial accessibility to PDS for different modes of travel for the eligible populations within Victoria; (2) estimate the oral health needs for the refugee populations at a small-area level based on their aspatial characteristics and visualize the spatial pattern of these estimated needs and (3) integrate the spatial accessibility to PDS and estimated oral health needs to highlight the areas with discordance in accessibility relative to the need for the refugee populations in Victoria.

## 2 | METHODS

The study employed an exploratory ecologic design at statistical area level 2 (SA2) in the state of Victoria, Australia. SA2s are census-defined geographical units approximated to align with one or more suburbs in the metropolitan areas and represent 'functional communities' that are socially and economically interactive, in the rural areas.<sup>24</sup> According to Australian Bureau of Statistics (ABS) 2016, there are 458 SA2s with resident population, of which 348 had refugee population.<sup>24</sup> All SA2 boundary files were available from ABS.

The study objectives were addressed in three stages (Figure S1). Measures used for spatial and aspatial components of access are independently developed in the first two stages, respectively. Finally, the two components are integrated in order to comprehensively examine access to PDS for refugees in Victoria. The study data and methods are described in detail in Appendix S1.

### 2.1 | Measuring spatial access

A widely used operational measure of spatial dimension of access is 'spatial accessibility', which combines two integral components - accessibility and availability.<sup>25</sup> When assessing spatial accessibility to dental care, provider-to-population ratio and distance to the nearest service have been extensively used.<sup>21,26-28</sup> While these measures are considered simple and intuitive, they provide an incomplete measure of spatial accessibility and are often criticized for their methodological limitations; they do not account for inequitable distribution of services, reciprocal effect of impedance (distance or travel time) on access or cross-border service access.<sup>25</sup> Gravity-based models, such as the sophisticated two-step floating catchment area (2SFCA) method, have largely addressed these limitations.<sup>3</sup> This study employed the novel and widely validated enhanced two-step floating

catchment area (E2SFCA) method, which is an offset of the conventional 2SFCA method, proposed by Luo and Whippo.<sup>29</sup> An additional variable catchment size function was also incorporated into the method, as proposed by McGrail and Humphreys.<sup>30</sup> The details of the E2SFCA calculations are provided in Appendix S1. In short, the E2SFCA method considers three input elements – location and capacity of *supply*, location and size of *demand*, and *impedance* between the supply and demand locations along a specific transport network – and spatial accessibility is calculated as the ratio of supply and demand, while accounting for impedance between their locations.

In Victoria, PDS are delivered through community dental clinics (CDCs). As of 2020, there were in total 85 fixed CDCs, of which 79 deliver services to all eligible population, while services in the remaining CDCs are restricted to a specific group (children, indigenous or homeless people). In line with the focus of this study, only the former 79 CDCs were included as supply elements. The CDC locations were geocoded, and service capacity of each CDC was represented by the number of full-time equivalent (FTE) dental professionals, including dentists, dental and oral health therapists, dental assistants and students (Table S1).

Estimates of the whole population eligible for PDS at SA2 level were used to represent the size of the potential demand. This is because the E2SFCA cannot be used to directly measure the spatial accessibility for the refugee population alone, as it would not be appropriate to assume that CDCs serve only the refugee population.<sup>31</sup> Therefore, in order to accurately model the demand for the CDCs, the entire eligible population were included as the potential demand. The eligible population for PDS in Victoria comprises all children below 12 years, adolescents aged 13–17 years who are in out-of-home or custodial care, all health care or pensioner concession card holders and their dependents, all refugees and asylum seekers.<sup>17</sup> Population estimates for each group were gathered from various publicly available data sources at SA2 level (Table S1). Refugees were identified from the Australian Census and Migrants Integrated Dataset (ACMID), 2016,<sup>16</sup> based on the Humanitarian visa categories (Refugee, Special Humanitarian and Other Humanitarian Programs), as defined by the Department of Home Affairs.<sup>32</sup> Due to unavailability of data on adolescents aged 13–17 years in out-of-home or custodial care, and dependents of card holders, at the SA2 level, all individuals aged 13–17 years were used to approximate the population of this eligible group. Population-weighted centroids of each SA2 were generated and represented the point locations of the corresponding eligible population (details in Appendix S1).

Impedance between SA2 population-weighted centroids and PDS locations was measured using *travel times* along road and public transit networks for Victoria, representing travel by driving and public transit modes, respectively. The two travel modes were considered to capture every possible way by which the study population can travel to PDS in Victoria. A multimodal network was built from the road and public transit network datasets gathered from the Department of Environment, Land, Water and Planning and Public

Transit Victoria, respectively.<sup>33,34</sup> The origin–destination cost matrix tool was used to generate travel times. All analyses were conducted within the network analysis module in ArcGIS Pro 2.6 (details in Appendix S1).<sup>35</sup>

## 2.2 | Measuring aspatial access

Traditionally, oral health needs are measured using normative (clinician-assessed) or subjective (self-assessed) methods.<sup>36</sup> However, such data are unavailable and difficult to obtain at a smaller geographic scale (e.g. SA2), especially for population groups like refugees who are considered to be largely 'hidden' or less connected with the systems.<sup>37</sup> There is substantial evidence demonstrating a strong association between socioeconomic gradient and the burden of poor oral health outcomes (or higher needs for oral health care) such as dental caries experience and oral health related behaviour,<sup>8,38</sup> including for refugees.<sup>39</sup> Therefore, in this study, a surrogate indicator of the extent of oral health care needs among the refugee populations was obtained at a population level using candidate variables.

Following previous studies, and based on a literature review (details in Appendix S1), eight potential variables related to socioeconomic status and acculturation have been identified for use in the estimation of refugee oral health needs within each SA2.<sup>40,41</sup> These variables were collected specific to the refugee population in each SA2 and all data were extracted from ACMID, 2016.<sup>16</sup> Of these, the following six variables were finally used in the oral health needs calculation based on their weak, but significant, association with the rates of emergency PDS use by refugees in Victoria between July 2016 and June 2020, also at the SA2 level (Appendix S1). Emergency use indicates a failure to receive appropriate preventative dental care<sup>42</sup> or delaying access to needed care,<sup>43,44</sup> which largely reflect the unmet needs in the population. Thus, the oral health needs indicator modelled upon rates of emergency PDS use provides the best estimate of refugees' need for oral health care. All variables were calculated as proportion of refugees to the total refugee population within each SA2 ( $r$  – Pearson correlation coefficient);

1. not completed Year 12 ( $r = .156, p = .004$ )
2. not proficient in spoken English ( $r = .185, p = .001$ )
3. arrived within last 5 years ( $r = .180, p = .001$ )
4. above 15 years and unemployed ( $r = .116, p = .030$ )
5. need assistance with core activities ( $r = .149, p = .005$ )
6. living in households without a motor vehicle ( $r = .167, p = .002$ )

Principal components analysis (PCA) was conducted to reduce the dimensionality of these variables and obtain one unified measure of oral health needs of the refugee population for each SA2 (herein OHN scores).<sup>45</sup> Based on the Kaiser's criterion, three principal components (75.2% total variance captured) with eigenvalues greater than one were combined using their respective eigenvalues as weightings (Appendix S1). PCA was conducted in Stata 17.

## 2.3 | Integrating spatial and aspatial components

The last stage involved integrating the spatial and aspatial components of access developed above to comprehensively examine access to PDS for refugees in Victoria. First, an index was created separately for the spatial accessibility and oral health needs components using standardized z-scores of their respective calculated scores (i.e., spatial accessibility and OHN scores), following the approach outlined in previous studies.<sup>46,47</sup> Standardization using the z-score expressed the accessibility and OHN scores in terms of their standard deviations (SD) from their respective means, where the mean is given a value of zero. Each SA2 was classified into one of the three groups representing the levels of spatial accessibility to PDS and refugee oral health needs, based on the respective components' z-scores, 'High' (z-scores  $\geq 1$ ), 'Medium' (z-scores between  $-1$  and  $1$ ) and 'Low' (z-scores  $\leq -1$ ). For example, an SA2 with an accessibility z-score  $\leq -1$  would be considered as having 'Low' accessibility to PDS, while an OHN z-score  $\geq 1$  would indicate 'High' refugee needs. All z-scores corresponding to one SD from the mean, including the mean ( $-1$  to  $1$ ), are considered 'Medium'. This step enables the transformation of the numerical scores of the accessibility and oral health needs components of each SA2 into categorical indices, the spatial accessibility index (SPAI) and refugee oral health need index (ROHNI).<sup>46</sup>

The two indices, SPAI and ROHNI, were finally integrated into a single index to highlight disparities in spatial accessibility relative to the oral health needs among the refugee population across Victoria. For example, a 'High needs-Low accessibility' SA2 can be identified, where the refugee oral health needs are estimated as high, but the spatial accessibility to PDS is relatively poor. The cross-classification of the indices was further categorized as over-served, well-served, moderately-served and under-served to represent the magnitude of discordance.<sup>46</sup>

## 3 | RESULTS

### 3.1 | Spatial accessibility to PDS

There are a total of 353.9 FTE dental professionals in 79 CDCs included in this study (43 CDCs or 67.7% FTE in the metropolitan areas, while the rest are in the rural areas). In general, spatial accessibility is higher in the metropolitan areas than rural areas, by both driving and public transit modes (Figure 1 and Figure S2). When comparing between the two transportation modes, accessibility generally decreases by public transit mode than driving mode, in both metropolitan and rural areas.

Figure S2 shows accessibility to PDS by driving mode using z-scores. Generally, clusters of high accessibility are seen in core metropolitan areas, as well as in and around regional centres. As the distance increases from these clusters, a gradual decrease in the accessibility is noted, particularly along the metropolitan-rural fringe and other rural areas. The SPAI by driving mode shows a clear difference in the levels of accessibility to PDS between metropolitan and

rural areas (Figure 1A). The majority of metropolitan SA2s have 'High' or 'Medium', while a few SA2s along the metropolitan fringe have 'Low' accessibility. Rural areas, excluding the SA2s in and around the regional centres, tend to have 'Medium' or 'Low' accessibility.

Accessibility by public transit mode shows substantially lower accessibility to PDS than driving mode (Figure S2). This contrast is particularly evident within the rural SA2s. The SPAI for public transit mode shows that the accessibility is 'High' or 'Medium' in the metropolitan areas and regional centres, with a sharp change to 'Low' levels towards the peripheries of these SA2s (Figure 1B).

### 3.2 | Estimated oral health needs of the refugee population

Figure 2 visualizes the ROHNI created using OHN scores of the SA2 refugee population. There is an evident disparity between the estimated needs of refugees in metropolitan and rural SA2s. Among rural SA2s with refugee population, 47.6% SA2s are classified as 'High' needs, while only 10.7% are in 'Low' needs category. On the other hand, 25.4% and 19.8% of metropolitan SA2s are 'High' and 'Low', respectively. The majority of the SA2s are classified as 'Medium' needs. Approximately 29% of all SA2s with refugee population are in the 'High' needs category, which comprise 19.8% of the total Victorian refugee population.

### 3.3 | Integrated need-accessibility index

The ROHNI and SPAI for the two travel modes are integrated in Figure 3. When examining accessibility by driving mode, the majority of the SA2s (44.5%) with refugee population were identified to be moderately-served with 'Medium (need)-Medium (accessibility)' values, followed by under-served with 'High-Medium' values (Figure 3A). Clusters of these are seen in the core metropolitan and the metropolitan-rural fringe areas. Other moderately- and under-served areas include 'Low-Low' and 'Medium-Low' and 'High-Low', respectively, which together comprise only 14.9% of the SA2s. The areas of most concern would be the under-served SA2s, including 'High-Medium', 'Medium-Low' and 'High-Low' values, which are associated with poor accessibility to PDS. In total, there are 111 under-served SA2s representing 30.4% of the total refugee population. In contrast, these are over- and well-served SA2s, which have relatively better accessibility in comparison to the need (e.g., 'Low' refugee needs and 'High' accessibility to PDS) (Table 1). These are spread out across the state, with small clusters seen in the metropolitan and rural areas.

Integrated need-accessibility index for public transit mode showed a clear contrast to that of driving mode (Figure 3B). There is a more marked increase in the number of under-served SA2s in the rural areas, including 'High-Medium', 'Medium-Low' and 'High-Low', with 18% of resident refugee population. Moderately-served SA2s with 'Medium-Medium' and 'Low-Low' values accounted for 42% of

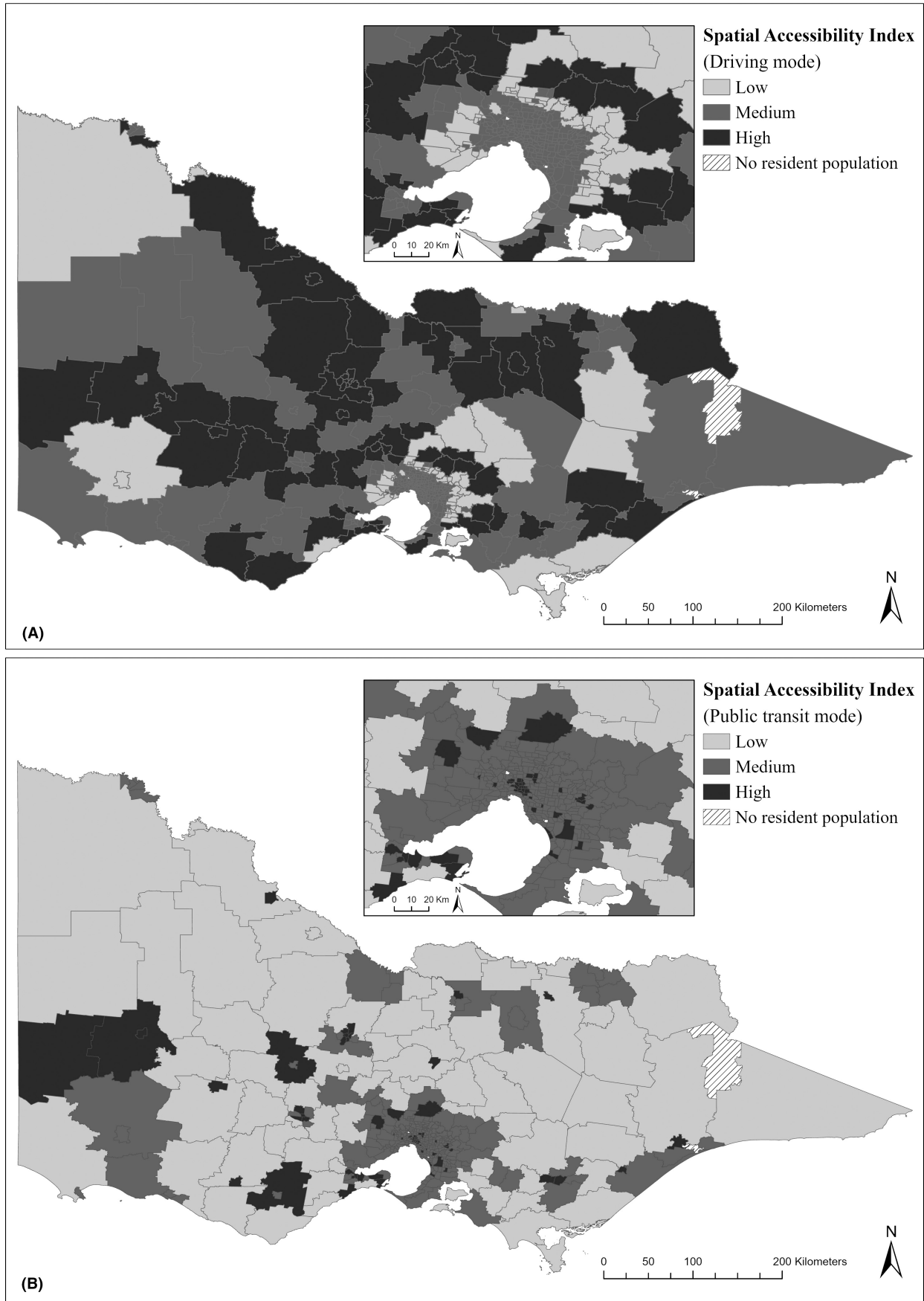
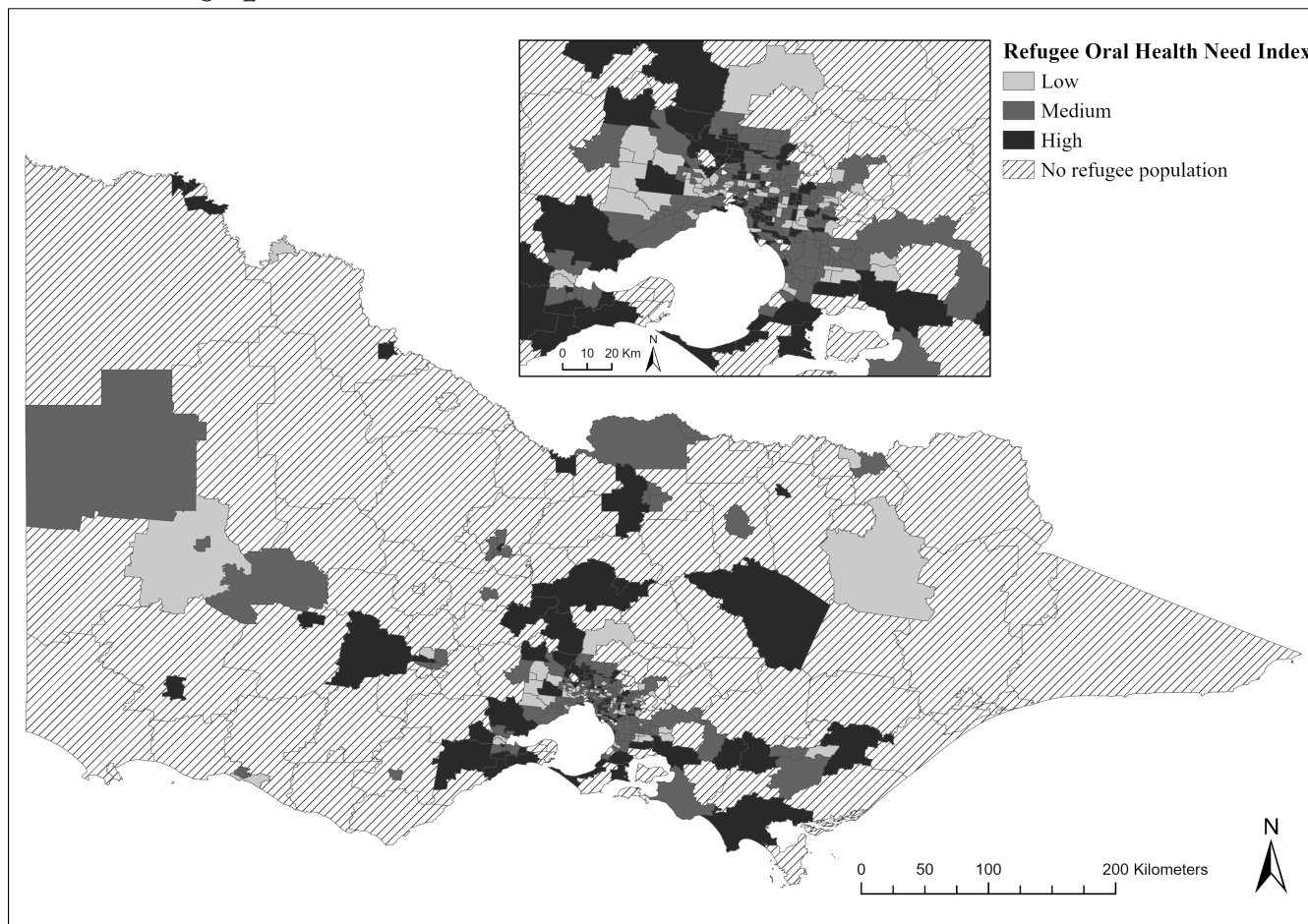


FIGURE 1 Spatial accessibility index for (A) driving mode and (B) public transit mode (inset shows enlargement of Melbourne metropolitan area).



**FIGURE 2** Refugee oral health need index representing refugee populations with high, medium and low needs (inset shows enlargement of Melbourne metropolitan area).

all the SA2s with refugee population, which is lower than that of driving mode (48.6%) (Table 1). Conversely, over- and well-served SA2s dominated the metropolitan areas, similar to the patterns of accessibility by driving mode.

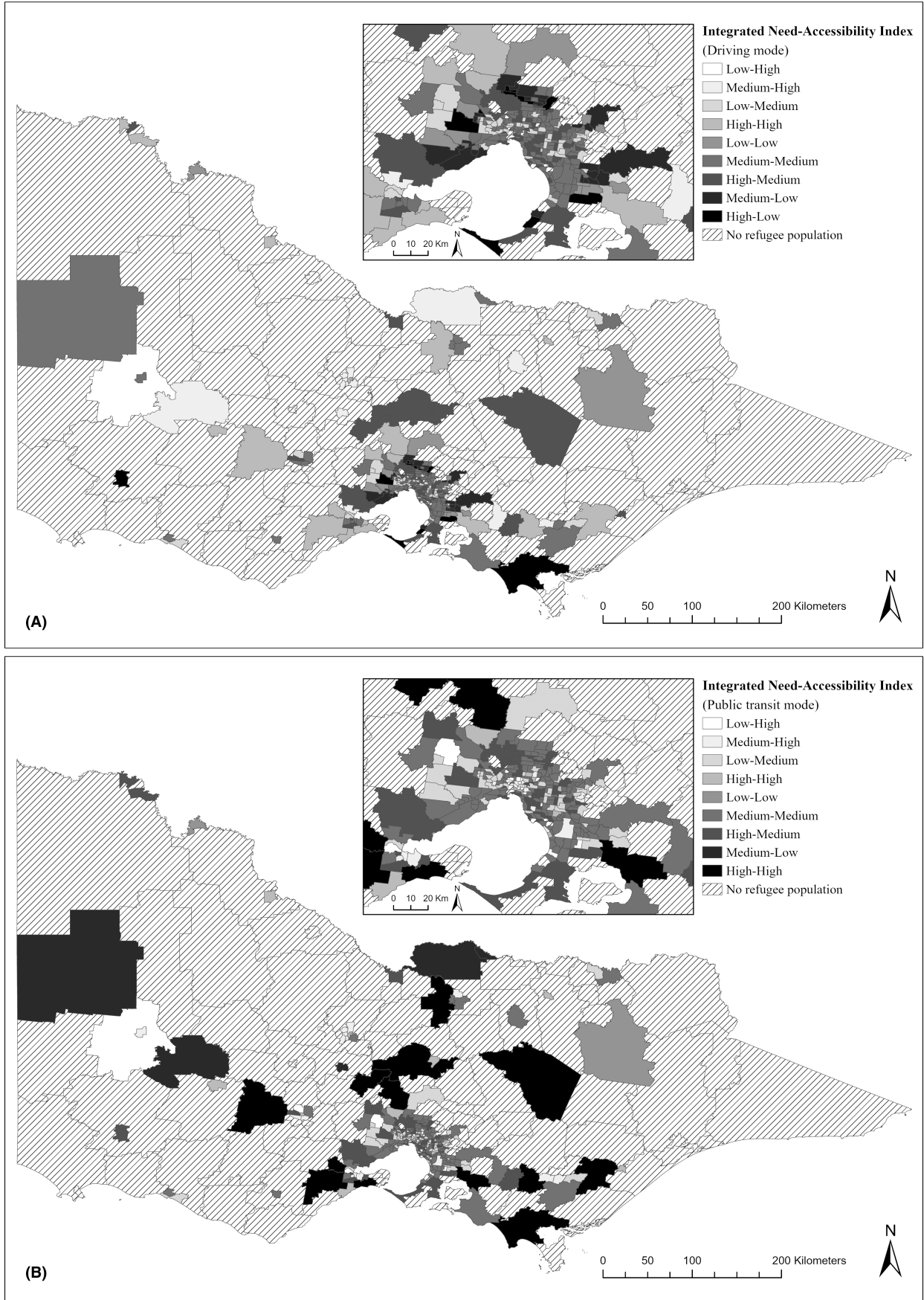
#### 4 | DISCUSSION

The key strength of this study is the integrated evaluation of spatial and aspatial dimensions of access to dental services for a specific population group (i.e., refugees in Victoria). Spatial and aspatial components of dental care access are often examined separately, limiting full understanding of access problems. Where attempts have been made to combine both components, descriptive or oversimplified approaches were used in the spatial accessibility analysis, often in combination with area-based deprivation measures or socioeconomic disadvantage indices (e.g., The Index of Relative Socioeconomic Disadvantage).<sup>26,48</sup> In this study, the more sophisticated E2SFCA model was used to measure spatial accessibility to dental services by two travel modes. Additionally, an indicator of the oral health needs for a specific population group was calculated at a small geographic scale using select population-specific

census-derived socioeconomic variables associated with the utilization rates of emergency dental services.

Disparities in the availability of transportation have been recognized as a significant barrier to access to dental services in Australia,<sup>23</sup> in general, and in Victoria, in particular.<sup>18</sup> By evaluating spatial accessibility by driving and public transit modes, a broad spectrum of transportation barriers for the eligible population (including the vulnerable refugee group) were also considered in this study. Given the lack of a generally accepted designation system to determine dental service shortage areas in either Victoria or Australia (e.g., dentist-to-population ratio), a SPAI was developed at the SA2 level to inform critical cut-off points for high- and low-accessibility areas. Overall, the index revealed limited accessibility to PDS for the eligible populations living in the rural areas and those dependent on public transit mode for travel. Thus, findings point towards the need for increased focus on provision of PDS for these groups, to address the inequalities in accessibility.

Socioeconomic variables specific to the refugee population were used in estimating their oral health needs at a fine geographic scale and subsequently developing the ROHNI. This index helped in visualizing the spatial variations in need within the population and revealed that the areas with high refugee needs are widely distributed across the state, in both metropolitan and rural areas.



**FIGURE 3** Integrated need-accessibility index representing levels of need and accessibility, respectively by (A) driving mode and (B) public transit mode (inset shows enlargement of Melbourne metropolitan area).

TABLE 1 Summary statistics of integrated need-accessibility index

Classification	Integrated need-accessibility index	Driving mode			Public transit mode		
		No. of SA2s (%) <sup>a</sup>	Total refugee population (%)	Average accessibility score <sup>b</sup> (×10000)	No. of SA2s (%) <sup>a</sup>	Total refugee population (%)	Average accessibility score <sup>b</sup> (×10000)
Over-served	Low-High	1 (0.3)	12 (0.1)	8.0	12 (3.4)	1915 (2.8)	6.6
Over-served	Medium-High	13 (3.7)	4498 (6.5)	1.1	33 (9.5)	8621 (12.5)	7.6
Well-served	Low-Medium	49 (14.1)	9542 (13.9)	2.5	49 (14.1)	12105 (17.6)	1.5
Well-served	High-High	19 (5.5)	366 (0.5)	10.6	18 (5.2)	1451 (2.1)	7.1
Moderately-served	Medium-Medium	142 (40.8)	31057 (45.1)	2.5	144 (41.4)	32256 (46.9)	2.2
Moderately-served	Low-Low	13 (3.7)	2406 (3.5)	7.6	2 (0.6)	33 (0.1)	0.9
Under-served	High-Medium	72 (20.7)	10962 (15.9)	2.6	72 (20.7)	12144 (17.6)	1.8
Under-served	Medium-Low	27 (7.8)	7649 (11.1)	1.3	5 (1.4)	236 (0.3)	0.1
Under-served	High-Low	12 (3.4)	2340 (3.4)	1.2	13 (3.7)	73 (0.1)	0.6
Victoria total		348 (100)	68834 (100)	4.2	348 (100)	68834 (100)	3.2

<sup>a</sup>SA2s with resident refugee population.

<sup>b</sup>Spatial accessibility scores calculated using enhanced two-step floating catchment area method.

Although there is substantial evidence supporting the association between socioeconomic variables and oral health,<sup>8-10</sup> research involving development of an area-based index using these variables is limited in dentistry. Among the limited literature, indices were developed using census-derived socioeconomic variables for the entire population.<sup>49</sup> In contrast, the methodology provided in this study offers a tool for developing area-based oral health needs indices for various vulnerable population groups (e.g., children, older adults, Indigenous groups, etc.) when examining dental care access.

Achieving equitable access to dental care is considered important in improving oral health outcomes by many dental health systems and policymakers.<sup>1,23,50</sup> It follows that populations with higher needs must have relatively higher levels of accessibility to dental care for their oral health outcomes to be improved. In this study, this relationship was captured for the Victorian refugee population by creating an integrated need-accessibility index. By combining spatial accessibility to PDS and oral health needs of the refugees, at the SA2 level, the index enables researchers and policymakers to visualize under-served SA2s which are of critical concern. These are the areas where the needs of the resident refugee population are high and the accessibility to PDS is low. This is significant in guiding future oral health care planning in these areas, including possibly the extension of community outreach dental programs.

The findings of this study must be interpreted within the context of several limitations. The primary limitation may be linked to the scaling effect of the modified areal unit problem because of the use of SA2 as the geographical unit of analysis in the spatial accessibility calculations.<sup>51</sup> This decision was necessary due to the lack of availability of both eligible and refugee population data at a finer scale. The average size of SA2s significantly increases in the rural areas where the population is not homogeneously distributed. However, within the constraints of this study, population-weighted centroids were used to represent the locations of the residential populations more accurately.<sup>52</sup> Despite these measures, pockets of variations in accessibility within each SA2 may be unidentified. Also, the refugee population data used in this study were from 2016. Considering the estimated annual population growth and the influx of new refugees since 2016, the current sociodemographic make-up of the population groups would be different. Upon the availability of next census population data, the study findings can be updated. Another possible limitation is the use of an oral health needs measure derived from socioeconomic variables associated with utilization rates of emergency dental services. It must be noted that the emergency services may also include management of orofacial trauma, such as avulsed or fractured tooth and temporomandibular joint dislocation.<sup>53</sup> Hence, the oral health needs measure thus obtained does not reflect the actual extent of untreated oral diseases among the refugee populations but only provides an estimate of the need for oral health services. However, owing to the lack of small-area level data on refugee oral health needs in Victoria, such a measure was used to capture a large part of the variation in per capita need across different areas.

It is acknowledged that the findings of this study have not been externally validated, and that subsequent validation is very



important prior to any policy decisions related to planning oral health services in Victoria. Lack of relevant data precludes any validation at this stage. Possible data for validating the spatial accessibility measure may be gathered through state-wide surveys from representative samples of refugee populations from each SA2 (or a finer geographic scale) on their perceptions of issues impeding access to PDS. Surveys may also include feedback from stakeholders (e.g., community dental agencies, dental professionals and support staff, refugee support organizations) with extensive knowledge on service provision. For the oral health needs measure, clinical data on the prevalence of oral disease may be obtained using decayed, missing and filled teeth scores or community periodontal index scores, again at a sufficiently small geographic scale. Comparing the survey findings on access in conjunction with the oral disease prevalence data could be used to determine if the refugees living in 'under-serviced' areas identified in this study perceive to have worse accessibility and higher oral health needs than those living in other areas (i.e., moderately-, well- and over-serviced). Finally, the methodology used in this study may also be validated by applying in different contexts, i.e., other population groups and in other locations both within and outside Australia, where better data may be available to researchers.

Notwithstanding the limitations, this study makes an important new contribution to understanding access to PDS for the Victorian refugee population, at a fine geographic scale. With 50% of the newly arriving refugees and other humanitarian migrants expected to resettle in the rural areas by 2022,<sup>54</sup> the findings of this study reiterate the critical need to address limited accessibility to PDS in the rural areas with poor availability of public transit. The various categories of accessibility and need revealed by the indices can also guide further qualitative research to investigate individual barriers and facilitators of PDS use for populations living in these areas.

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#### CONFLICT OF INTEREST

None to declare.

#### DATA AVAILABILITY STATEMENT

Population, spatial and transportation network data that support the findings of this study were derived from following resources available in the public domain: <https://www.abs.gov.au> and <https://discover.data.vic.gov.au>. The detailed list of data sources has been provided in Appendix S1. Location and attribute data for community dental clinics, and clinical and administrative data related to refugees are available from DHSV. Restrictions apply to the availability of these data, which were used under license for this study. Per the

data use agreement between DHSV, the Department of Health and Human Services, Victoria, and the authors, the authors cannot redistribute the data.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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