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# Assessing accessibility to healthcare facilities with public transport: A focus on older adults

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## 1 Introduction

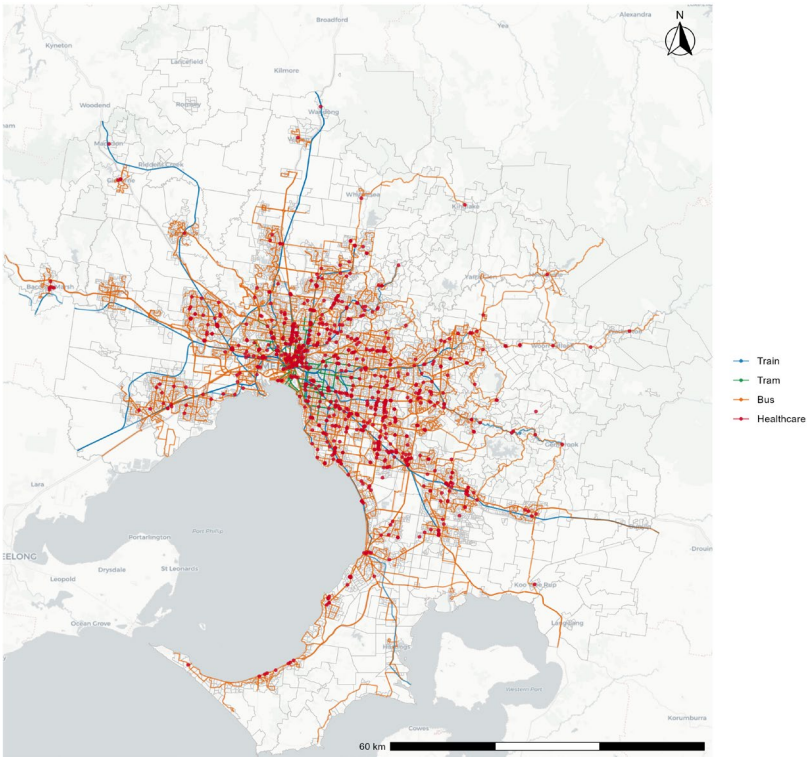
Public transport (PT) is essential for urban mobility, facilitating access to essential services, including healthcare, especially for vulnerable groups like older adults (OAs) (Buchanan, 2019; Matsuda et al., 2019). In this study, "OAs" refers to individuals aged 65 or older. An effective PT system can enhance their independence, social inclusion, and quality of life (Zhang and Yang, 2024). However, research has highlighted that OAs and other disadvantaged groups often experience inequities in PT accessibility compared to other groups (Adorno et al., 2018; Ricciardi et al., 2015). Limited PT access to healthcare is linked to poorer health outcomes, raising concerns about social equity and service utilisation (Boisjoly et al., 2020; Dai, 2010). This study aims to investigate the accessibility of healthcare facilities using PT modes in Greater Melbourne, focusing on both OAs and the general population. Specifically, examining whether OAs experience greater challenges in accessing healthcare facilities. A gravity-based metric is used to calculate travel times from each Mesh Block (MB) to healthcare destinations, with population-weighted models highlighting spatial inequalities. Unlike prior studies that focus on individual user groups or offer broad policy recommendations (Boisjoly et al., 2020; Ricciardi et al., 2015), this research provides a comparative analysis across demographic groups. It offers practical insights for urban planners to enhance PT services and address unmet healthcare needs, particularly in underserved outer Melbourne suburbs.

## 2 Methodology

### 2.1 Data sources

This study focuses on Greater Melbourne, Victoria, with a population of approximately 5 million, using mesh blocks (MBs) as the smallest geographic units. Data for PT schedules, routes, and stops were obtained from Public Transport Victoria's GTFS dataset ("PTV GTFS - OpenMobilityData," n.d.). Population data and travel survey data between 2012 and 2016 were sourced from the Australian Bureau of Statistics (ABS) and the Victorian Integrated Survey of Travel and Activity (VISTA) ("Department of Transport and Planning," 2023). The locations visited by the VISTA cohort were determined to obtain detailed insights into the various types of points of interest (POIs) and to quantify the frequency of trips to these POIs. Upon identifying the destination types (healthcare facilities) from VISTA data, the Overpass Turbo API was utilised to retrieve the location data of all healthcare points of interest.

**Figure 1: Greater Melbourne PT network with the location of all healthcare POIs at SA1 level**




## 2.2 Travel time estimation

Travel times from each MB centroid (origin) to healthcare facilities were estimated utilising the r5r package, an R tool designed for transport analysis (Pereira et al., 2021). The calculation used 9 AM as the peak travel time, based on VISTA data showing this as the busiest hour for OA healthcare trips.

## 2.3 Accessibility calculation

The research employed a gravity-based accessibility metric to assess healthcare access through PT, considering spatial and temporal factors. This metric assigns a higher weight to closer healthcare facilities, reflecting the reduced likelihood of long-distance travel. For OAs, the accessibility score was population-weighted, adjusting the score based on the proportion of OAs in each mesh block (MB). The key formula used for accessibility is:

$$A_i = \sum_{j=1}^{n} O_j f(C_{ij}) \quad (1)$$

Where:

$A_i$ is the accessibility score of the mesh block $i$,which indicates the ease of accessing POIs from an MB.

$n$ is the total number of POIs of type healthcare reachable within a time threshold (T).

$O_j$ is the number of healthcare POIs available at destination location j, including those within the MB or reachable within T. For simplicity, we consider all POIs of a type to have equal opportunities; therefore, $O_j$ is set to 1 for all $j$.

$f(C_{ij})$ is the impedance function that quantifies the friction experienced during travel between two points, $i$ and $j$.

$f(C_{ij})$ is an exponential function Eq.2:

$$f(C_{ij}) = e^{-\beta C_{ij}} \quad (2)$$

Where:

β is the impedance parameter reflecting sensitivity to the travel cost, and $C_{ij}$ is the travel cost between location $i$ and $j$ (in this research, travel time represents the travel cost).

The impedance function, using an exponential decay formula, assigns greater value to destinations with shorter travel times. A 30-minute travel time criterion was implemented, consistent with the "30-minute city" paradigm. This concept reflects a shift to create a more accessible, equitable, and sustainable city (Birkenfeld et al., 2023; Levinson, 2019).

Accessibility scores for older adults (OAs) were computed by considering the population distribution of OAs, represented by the weight (w), which quantifies the proportion of OAs in each mesh block relative to its corresponding Statistical Area 1 (SA1), given by equation below:

$$PWA_i = w_{ik} \sum_{j=1}^{n} e^{-\beta \cdot C} ij \quad (3)$$

Where:

$w_{ik}$ is the weight variable representing the proportion of the OA group population in the mesh block to its respective SA1.

The individual accessibility scores of mesh blocks were then aggregated to the SA1 level. Aggregation was performed to stabilise the accessibility scores by averaging variations across multiple MBs. The average of the mesh block scores within the SA1 boundary is calculated, as shown below:

$$A_R = \frac{1}{m} \sum_{i=1}^{m} A_i \quad (4)$$

Where:

$A_R$ is the aggregated accessibility score for the SA1 region R.

$m_R$ is the total number of mesh blocks within each SA1 region R.

Spearman's correlation was applied to analyse the relationship between PT accessibility and actual healthcare trip demand to validate the results. We calculated the trip rates for each cohort to assess the average number of trips made per individual in a specific cohort to healthcare facilities. This approach was adopted to standardise the varying sample sizes of both cohorts in the VISTA data. The trip rate is determined by the following equation:

$$Trip\ Rate\ (T_r) = \frac{Total\ Trips\ by\ each\ cohort}{Sample\ size\ of\ the\ cohort} \quad (5)$$

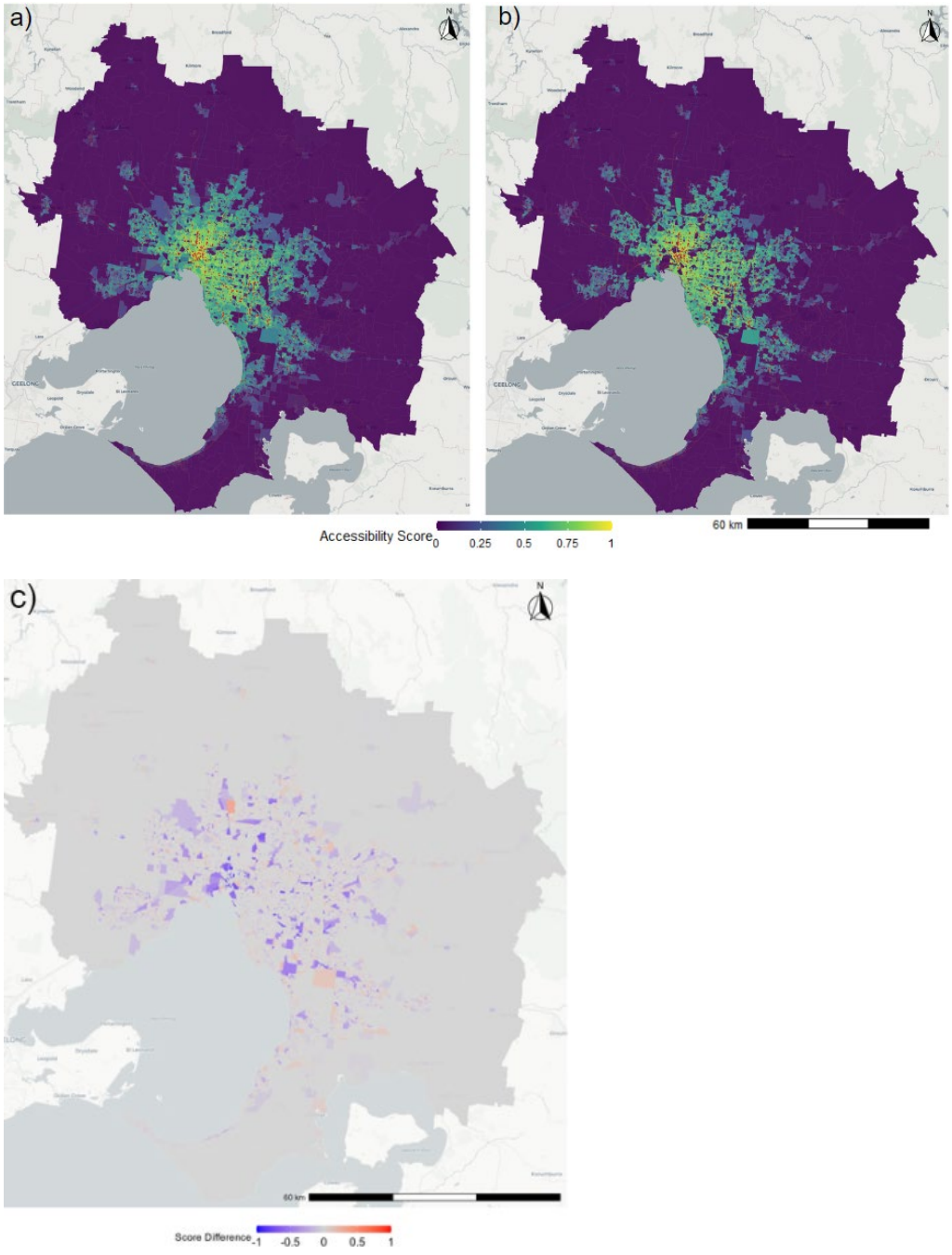
# 3 Main findings

## 3.1 Spatial distribution of public transport accessibility

The accessibility scores reveal disparities across Greater Melbourne, with inner Melbourne showing higher scores due to a well-integrated PT network and numerous healthcare facilities. In contrast, outer suburban areas show significantly lower accessibility. Figure 2 (a) illustrates the distribution of the aggregated accessibility score in Greater Melbourne at the SA1 level, computed using Equation (1), and Figure 2 (b) below depicts the accessibility levels for OAs to healthcare facilities. The scores are derived from a 30-minute travel duration to healthcare facilities utilising PT. The scores vary from 0 to 1. An accessibility score of 1 signifies that the healthcare destinations are ideally accessible from the specified SA1 location. An accessibility score of 0 signifies a minimal level of accessibility. This indicates that accessing healthcare facilities from the specified SA1 is virtually unattainable within 30 minutes of PT.

These findings highlight an uneven distribution of PT services and healthcare facilities, with OAs facing greater accessibility challenges compared to the general population. Although both groups benefit from inner Melbourne's infrastructure, OAs consistently have slightly lower scores. Figure 2 (c) illustrates these differences, where blue-to-red gradients highlight regions where general populations have higher accessibility scores than OAs. The lower accessibility scores for OAs may result from limited PT service, long transfer times, or inadequate healthcare facilities nearby. Addressing these disparities requires both expanding PT services in underserved regions and strategically increasing healthcare facilities near residential areas. Improving service coverage would particularly benefit OAs living in outer Melbourne, where residents currently struggle to access healthcare via PT.

**Figure 2: (a) average PT accessibility to healthcare facilities (SA1 level), (b) OAs access to healthcare with PT (SA1 level), (c) difference in accessibility score between OA and the general population.**




## 3.2 Accessibility and healthcare trips

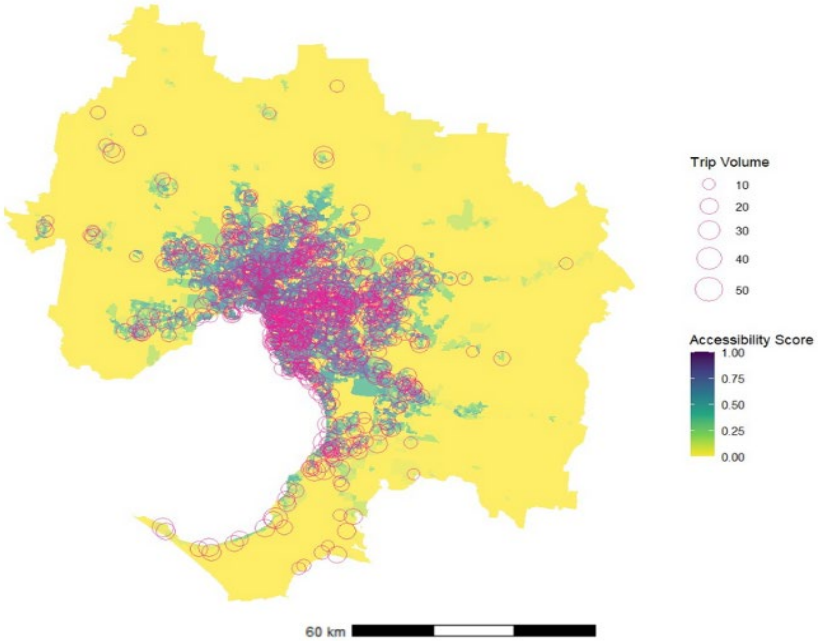
Understanding per capita demand is essential for evaluating the adequacy of existing PT services and planning for future needs. VISTA data shows that OAs make more healthcare trips (0.055 trips/person) than the general population (0.026 trips/person), highlighting their greater reliance on healthcare services and the importance of accessible PT. However, OAs tend to use private vehicles more often than PT, indicating barriers within the public transport system. Table 1 presents the trip frequencies by transport mode for both cohorts.

**Table 1: Comparison of transport mode usage between older adults and non-older population segments**

| Population Group | Active Mode | Public Transport | Private Mode | Total Trips |
|---|---|---|---|---|
| Older adults (OAs) | 17 | 22 | 603 | 542 |
| General population | 56 | 38 | 832 | 926 |

Spearman's correlation analysis was conducted across all Greater Melbourne's SA1s. The correlation between the calculated accessibility score and the trip volume to hospitals from all SA1s resulted in a correlation coefficient of 0.0537, indicating a very weak positive correlation. The weak correlation indicates that although higher PT accessibility aligns with increased healthcare trips, other factors such as socio-economic conditions and travel preferences may also play a role. Figure 3 below shows the accessibility and trip counts for each SA1 in Greater Melbourne.

**Figure 3: Healthcare trips and SA1 accessibility score in Greater Melbourne**




The spatial analysis further highlights discrepancies, showing that some outer suburban areas generate significant healthcare trip demand despite having low accessibility scores. This mismatch suggests unmet transport needs that current PT services fail to address.

# 4 Discussion

The findings underscore the spatial disparities in healthcare accessibility throughout Greater Melbourne, with inner urban areas benefiting from superior access to healthcare through public transport compared to outer suburban regions. This disparity indicates that the existing PT infrastructure may inadequately address the requirements of residents, especially OAs, in peripheral regions. Enhancing PT services in underserved areas, either by increasing service frequency or establishing new transit routes, could mitigate travel barriers and promote social equity. Additionally, strategically placing healthcare facilities closer to residential areas with high OA populations would address accessibility gaps. Addressing the unmet travel needs identified through this study could also help achieve broader sustainability goals by encouraging greater reliance on PT, thereby reducing the environmental impact of private vehicle use. This study contributes to transport equity literature by comparing accessibility

between OAs and the general population, offering a more comprehensive analysis than prior studies focused on single groups. The use of population-weighted gravity-based metrics provides a nuanced understanding of accessibility disparities. While this study offers valuable insights, the limitations of this study must be acknowledged. The use of a 30-minute travel threshold may not fully capture the needs of all users, particularly those in remote areas who require longer trips. Additionally, the model does not consider factors such as service frequency, reliability, or congestion, which may impact travel experiences. The VISTA dataset reflects older travel patterns (2012–2016), and future research should use updated data to capture current trends. Finally, this study focuses only on PT-based accessibility, excluding other modes like ride-sharing or active transport, which could also influence healthcare access.

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