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The impact of perceived racism on walking behavior during the COVID-19 lockdown

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ABSTRACT

The COVID-19 pandemic lockdown has had a significant impact on people’s travel behavior. The level of this impact has been unevenly distributed among different population groups. The recent rise in anti-Asian racism implies that Asians have faced increased stress during the pandemic. As a result, the impact on their travel behavior is likely to differ from other ethnic groups. We examined this hypothesis by focusing on the impact of the pandemic on walking behavior. We collected survey data in Melbourne, Australia, during the pandemic lockdown, and analyzed the data using a Structural Equation Model approach. The results suggest that Asians experienced a significantly higher level of discrimination than other racial groups and were less likely to increase walking than White people. We also found that neighborhood cohesion helped alleviate perceived discrimination and promote walking. This study offers new insights into the role of racism in travel behavior.

1. Introduction

The COVID-19 pandemic dramatically impacts people’s travel behavior, significantly influencing their lives and wellbeing. An increasing number of studies from different countries and regions have investigated travel behavior impacts of the pandemic. They have reported relatively consistent findings, such as a significant decline of travel frequencies and distances, a plummeting transit ridership, and a boom in active travel (e.g., walking and cycling) (Abdullah et al., 2020; Beck and Hensher, 2020; Habib and Anik, 2021). However, the impact of the pandemic on travel behavior is not equally imposed on the population (Hu and Chen, 2021; Tao and Cao, 2021). Some population groups suffer more from the pandemic because of institutional barriers (e.g., lack of accessibility), COVID-19 induced social issues (e.g., racism), or both. Asians, for example, have faced a double whammy of the pandemic and the anti-Asian racism. As a result, Asians have disproportionally faced more stress and anxiety when exposed to the outdoor environment during the pandemic, considerably impacting their travel behavior. While many studies have investigated the variations in travel behavior between different racial or ethnic groups (Kim and Ulfarsson, 2021; Shin, 2017; Smart, 2015), little research has examined the role of racial discrimination in travel behavior, particularly under the pandemic context. Exploring this research question is important for us to understand the role of discrimination in travel decisions and address the challenge of transportation equity in a public health crisis.

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In this study, we focus on the walking behavior impact of the pandemic for three reasons. First, compared with other modes of transport, walking is more likely to be exposed to the outdoor environment, thus making pedestrians more vulnerable to racial discrimination. Second, walking plays an important role in fulfilling people’s travel needs and thus improving their eudaimonic wellbeing (Ettema and Smajic, 2015; Singleton, 2019). This is particularly important during the lockdown period when Australians’ travel is strictly restricted to a particular small area within their neighborhood. Third and more importantly, walking is not just a travel mode but provides an important opportunity for recreation, excising, and social interactions, thereby mitigating the mental stress from the pandemic. The first aim of this study, therefore, is to examine the impacts of racial discrimination on walking behavior during the pandemic.

Furthermore, little research has investigated the role of the neighborhood environment in alleviating racial discrimination in the pandemic. The built and social environment of a neighborhood might help mitigate racial conflicts and improve inter-racial harmony by promoting positive inter-racial interactions and cross-cultural communications. The second aim of this study is to identify specific neighborhood characteristics that are beneficial to reduce the racial stigma.

By establishing the link among the neighborhood environment, racial discrimination, and walking behavior, this study contributes to a new conceptual framework that better illustrates travel behavior in a public health crisis. The findings of this study will inform urban and transportation planners on how to advance racial equity, thereby improving active travel when the next emergency arises.

2. Literature review

2.1. The impact of COVID-19 on travel behavior

The COVID-19 pandemic has generated a significant impact on people’s daily travel. To curb the spread of Coronavirus disease, various travel restrictions and bans were implemented in many countries and cities. In Australia, for example, four levels of travel restrictions, from stage 1 to stage 4, have been implemented. Under the stage-4 lockdown, which is the highest level of travel restriction, residents are only allowed to travel within a 5-km radius of their homes and for four essential reasons, including shopping, working or studying, seeking health care, and exercising. These restrictions have significantly impacted the frequency and distance of people’s travel, and how and where they travel. For example, commuting trips, which make up the most significant proportion of daily traffic flow, have plummeted, as most employees have been forced to work from home during the pandemic (Frumkin, 2021). Studies, based on the data from different countries, have reported that people’s daily travel becomes less frequent and shorter in the distance, and shopping and recreation become the primary travel purposes during the pandemic (Abdullah et al., 2020; Beck and Hensher, 2020; Shaer and Haghshenas, 2021).

Along with the changes in travel distances, frequencies, and purposes, travel modes have also changed dramatically. As a result of the imposed travel restrictions, many people’s daily lives are restricted to their immediate neighborhoods. The restrictions encourage more people to walk and bike for either transportation or recreational purposes. In addition to the travel restrictions, the fear of being infected has also influenced people’s travel behavior. To reduce the risk of COVID-19 infection, many people choose to avoid or reduce the use of transit and shared mobility, promoting a shift of travel mode towards private cars and active travel (Currie et al., 2021; Eisenmann et al., 2021; Habib and Anik, 2021; Loa et al., 2021; Schaefer et al., 2021). For example, Hu and Chen (2021) found that 95% of Chicago bus stops were affected by the pandemic, leading to a 72.4% reduction in ridership. Based on a survey in Germany, Eisenmann et al. (2021) found that transit passengers declined by nearly half, while private cars became more important during the lockdown period. We have also seen a boom in bike and e-bike sales globally and a significant increase of bicyclists and pedestrians on the streets and trails in many countries during the pandemic lockdown (Doubleday et al., 2021; Frumkin, 2021; Habib and Anik, 2021; Shaer et al., 2021; Zhang and Fricker, 2021).

As an important means of physical activity, walking and bicycling provide opportunities for people to improve physical fitness and cope with the anxiety and depression associated with the pandemic. The imposed lockdown during the pandemic has resulted in various mental and physical health issues (Pierce et al., 2020). To combat these health problems, many people have started to engage more in outdoor activities, including walking and bicycling, to gain exercise and contact with nature during the pandemic (Frumkin, 2021). For example, the pandemic has induced more Italians to own and use bicycles after the pandemic, and people are pursuing a healthier and more sustainable lifestyle (Bergantino et al., 2021). Therefore, levels of walking and bicycling during the pandemic are important indicators that reflect individuals’ ability to cope with the impact of the pandemic. Those who have higher levels of walking and bicycling are more capable of maintaining their health and life conditions during the pandemic and thus are more resilient. As bike ownership and the terrain strongly influence bicycling behavior, we focus on examining the walking behavior impact of the pandemic in this study.

2.2. Roles of neighborhood environment and anti-Asian racism in walking behavior

Although there is an increasing trend in active travel due to the pandemic, this trend does not show a similar pattern in geographic spaces and among different populations. First, previous studies have suggested that the neighborhood environment, including built and social environments, influences walking behavior (Beenackers et al., 2013; Handy et al., 2002; Loukaitou-Sideris, 2016; Saelens and Handy, 2008). It is likely that people living in highly walkable neighborhoods are more likely to increase walking activities in the pandemic. Furthermore, unlike motorized modes, walking exposes pedestrians to the outdoor environment and is more likely to be immediately affected by neighborhood safety and security. Safe neighborhoods with lower crime rates improve social interactions between neighbors, and their residents are more likely to engage in walking activities (Aliyas, 2020; Beenackers et al., 2013).
Following the pandemic, there is an increase in COVID-19 related crimes (e.g., anti-Asian hate crime), and more than one-third of incidents occur on streets and sidewalks (Horse et al., 2021). A safe neighborhood environment free of racism, therefore, is critical for walking activities during the pandemic. Moreover, neighborhood social cohesion is positively associated with perceived safety (De Jesus et al., 2010), and therefore, a cohesive neighborhood environment may help improve walking during the pandemic. In addition, the racial/ethnic composition of a neighborhood may matter to walking behavior during the pandemic. Several American studies (Liu and Painter, 2012; Shin, 2017; Smart, 2015) have found that immigrants or ethnic minorities who lived in neighborhoods with a high concentration of their own ethnic population (often referred to as ethnic enclaves) are more likely to carpool, use active travel, and use transit. The significant relationship between ethnic enclaves and travel behavior is also attributable to social ties and social trust within the neighborhood, in addition to the built environment.

Second, Asians may have experienced a more significant impact of the pandemic on travel behavior due to the anti-Asian racism. After the outbreak of the COVID-19 pandemic, there was a surge of anti-Asian incidents globally. A study (He et al., 2020) surveyed 1904 overseas Chinese residents across 70 countries in the early period of the pandemic (February 2020) and found that around 25% of the respondents experienced various forms of discrimination. Another study (Wang et al., 2020) conducted in France also revealed that about 33% of people of Chinese ethnicity had experienced racism during the pandemic, particularly for young people (30 years old or younger). It further showed that racial discrimination frequently happened in public areas, including public transit, open public spaces, cafes, and restaurants. Asians, therefore, have to bear the combined shock from both the pandemic and racial discrimination. This overlapping effect may have well increased their transport difficulties, particularly walking behavior.

In addition to the impact on travel behavior, racial discrimination has also contributed to worse mental wellbeing of Asians during the pandemic. The COVID-19 pandemic has significantly affected people’s mental wellbeing (Pierce et al., 2020), but Asians may have experienced a greater impact because of the discrimination. For example, perceived discrimination during the pandemic was positively associated with poorer mental health among Chinese Americans (Cheah et al., 2020). Asian Americans were twice as likely to suffer discrimination as Whites during the pandemic and therefore experienced higher levels of mental disorders (Wu et al., 2020). As discussed above, walking provides an important means to mitigate the psychological impact of the pandemic. Examining the link between racial discrimination and walking behavior is important to better understand why the pandemic has impacted the wellbeing of Asians more severely than others.

2.3. The neighborhood environment and racism

The neighborhood environment could alleviate racism. The Contact hypothesis (Allport et al., 1954) provides a framework to understand the link between the neighborhood environment and racism. It suggests that close and consistent contacts between different ethnic groups can provide different values and promote positive, non-biased attitudes (Shinew et al., 2017). Occasional meetings and conversations between neighbors can serve as an important tool for cross-cultural communications (Dandy and Pe-Pua, 2015). The neighborhood is often the primary place where discrimination occurs (Shelton et al., 2009). Therefore, a neighborhood environment that promotes social contacts could be important to reduce racial discrimination. In terms of specific built environment elements, several studies have highlighted the positive effects of neighborhood green and open spaces on mitigating racial conflicts and discrimination. For example, Shinew et al. (2017) found that community gardens in a neighborhood play an important role in promoting positive inter-racial interactions. Rishbeth et al. (2017) suggested that parks are beneficial to racial integration because they provide opportunities for informal contacts that evoke a sense of place, which can in turn strengthen social bonds. Hoffman (2019) concluded that green spaces (e.g., community gardens, urban forests, etc.) could help bridge the gap between cultures and reduce violent incidents. Furthermore, neighborhood walkability might help mitigate racism. It is positively associated with social interactions (Leyden, 2009; Rogers et al., 2011; van den Berg et al., 2017), which in turn improve understandings and reduce conflicts between different racial groups.

In addition to the built environment, many studies have shown that the social environment is strongly associated with racism. The
sense of belonging plays a vital role in improving communication and eliminating discrimination (Dandy and Pe-Pua, 2015; Williams et al., 2003). Furthermore, social support and good social relationships help improve self-esteem and impose significant buffering effects in the relationship between perceived discrimination and mental health (Ajrouch et al., 2010; Dailey et al., 2010; Russell et al., 2018). A study on mainland Chinese immigrants in Hong Kong found that social support and community cohesion effectively alleviated the anxiety associated with perceived discrimination (Chou, 2012). Finally, according to a study of Hispanic/Latino American adults (Budd et al., 2021), perceived neighborhood safety may also have beneficial effects on reducing racial discrimination stress. Therefore, a positive social environment appears to have the potential to mitigate racism.

The review of previous studies points to significant gaps in the literature. First, little research has examined the impact of racial discrimination on travel behavior during the COVID-19 pandemic. Second, more studies are needed to explore how the neighborhood environment can help mitigate racial discrimination. Our study aims to shed light on these research questions by exploring how the anti-Asian racism that emerged from the COVID-19 pandemic has impacted walking behavior and how the built and social environment of residential neighborhoods might alleviate racial discrimination. Based on the above discussion, we propose a conceptual framework (Fig. 1) to examine three hypotheses: (1) Asians experience higher levels of perceived discrimination during the pandemic; (2) perceived discrimination has a negative impact on walking behavior; (3) neighborhood greenness, walkability, and social cohesion help reduce the perceived discrimination.

3. Methods

3.1. Data

In this study we analyzed data from a self-administered survey of adult residents in the Melbourne metropolitan area of Australia, collected during the COVID-19 lockdown period. Because of the travel restrictions of the lockdown, we worked with a local panel company that helped recruit participants. Before distributing the survey, we set up sampling quotas on age, gender, home location, and race, according to the census data. This helped improve the representativeness of our sample. The panel company has a database that allows us to randomly draw eligible participants based on our sampling quotas. The selected participants were then invited to participate in an online survey (based on Qualtrics) by email, and the progress of their responses could be monitored through the Qualtrics platform. This recruitment process continues until we reach the target sample size for each quota. Totally, the panel company recruited 1,827 residents to complete the survey between September 1 and 18, 2020. This period was the second stage-4 lockdown imposed in the Melbourne metropolitan area.

Of the respondents, 323 were removed because of “speedster activity”. In particular, because the panel company provided participants a direct monetary incentive, for quality assurance purposes, two “trap” questions were included in the survey to identify “speedsters” providing inaccurate information. These two questions were embedded in different sections of the survey, and those who incorrectly answered either of the two questions were not included for further analysis. Furthermore, we set up a minimum time required to fill out the survey, and those who could not meet this requirement were also identified as “speedsters.” In addition, 372 were screened out because of the sampling quotas making the final number of valid responses 1,132.

Even using the sampling quotas, our sample does not perfectly represent the population. The respondents tend to be younger, have more females, and have a higher median annual income than the population. Moreover, the percentage of Asians in our sample is somewhat higher than that in Greater Melbourne (Table 1). However, because we focus on the conditional relationship between racism and walking, rather than describing the univariate distributions of racism and travel behavior of the region, the over- or under-representation of certain groups of people in the sample is not likely to materially affect the results of multivariate analyses (Crano et al., 2015).

3.2. Outcome variables

We will examine how respondents’ perceived racism changes their walking behavior during the COVID-19 pandemic. We measured the change by asking the respondents to rate how their walking frequency had changed during the COVID-19 lockdown using a five-point Likert scale: 1-A lot less during the pandemic, 2-A little less during the pandemic, 3-Unchanged, 4-A little more during the pandemic, 5-A lot more during the pandemic. This measure indicates the impact of the COVID-19 pandemic on walking behavior. Overall, about 47% of the respondents reported walking more frequent during the pandemic than the pre-COVID time. Around 31% reported their walking frequency unchanged and about 21% reported walking less often.

| Table 1 | Sample versus population characteristics. |
|---------|------------------------------------------|
|         | Sample | Greater Melbourne |
| Female (%) | 53.0 | 51.0 |
| Age 55 and younger (%) | 89.0 | 81.0 |
| Married (%) | 58.4 | 48.4 |
| Education (median) | bachelor degree | diploma degree |
| Household income (median) | $80,000-$99,000 | $80,180 |
| East and Southeast Asian (%) | 16.0 | 12.9 |

The conceptual framework (as shown earlier in Fig. 1) illustrates that perceived discrimination during the pandemic directly affects walking behavior. It serves as a mediating variable connecting walking behavior and the neighborhood environment, as well as race. We measured perceived discrimination by asking the respondents to rate whether they had been treated with less respect than other people after the outbreak of COVID-19, using a five-point Likert scale: 1-Definitely not, 2-Probably not, 3-Might or might not, 4-Probably yes, 5-Definitely yes. Being treated with less respect or unfairly is one of the most commonly used measures for racial discrimination. Based on Williams et al. (1997), perceived discrimination essentially is an experience of unfair treatment. It is a key element of the widely used scales of perceived discrimination, including Everyday Discrimination Scale (Williams et al., 1997) and Experiences of Discrimination (Krieger et al., 2005). To ease respondents’ burden, we used a single item to measure perceived discrimination, although a latent construct underlying a few dimensions of discrimination is more desirable. Fig. 2 illustrates the different patterns of changes in walking behavior between those who perceived discrimination during the pandemic and those who did not. For those who felt discriminated, they were more likely to walk less and less like to walk more.

3.3. Explanatory variables

We used the race and socio-demographic characteristics of the respondents and their neighborhood environment features to explain perceived discrimination and changes in walking behavior. Based on the race reported in the survey, the respondents were categorized into three groups: White/Caucasian, East and Southeast Asian (called Asian for simplicity), and others. Around 73% of the respondents identified themselves as White/Caucasian. About 16% identified themselves as East and Southeast Asian, mainly Chinese, Korean, Japanese, Vietnamese, Malaysian, Indonesian, and the Philippines. In addition to race, we accounted for socio-demographics, which may be associated with perceived discrimination and walking behavior, including age, gender, and household income.

Neighborhood environment includes both the built and social environment. For built environment characteristics, we first measured the location of the neighborhoods by calculating the air distance from the centroid of each neighborhood to the city center (i.e., Melbourne Central Station). Based on the distance, respondents’ home locations were divided into four categories: inner city (within 5-km), inner suburbs (5–10 km), middle suburbs (10–20 km), and outer suburbs (20 + km). Similar distance cutoffs for categorizing locations of Greater Melbourne have been used in previous studies (Delbosc and Currie, 2011; Li et al., 2021a; Li et al., 2021b). Fig. 3 illustrates the spatial distribution of the respondents’ home locations. We then measured land-use and street network characteristics within each neighborhood. The measures contained bike lane density (including both on-street and off-street lanes), population density, the entropy index\(^1\) for land use mix, percentage of commercial land use, connected node ratio\(^2\) for street connectivity, bus stop density, train station density, and percentage of vegetation cover within the neighborhood. The data source for calculating these objective built environment variables came from DataVic (Victoria’s open data platform). To reduce the dimensions of the built environment variables, we applied a principal component analysis to all of the above but the percentage of vegetation, which was treated as an individual variable. One principal factor was extracted and named as walkability. Table 2 presents the loadings of built environment variables. The one extracted component explains about 60% of the variance. We have tested the internal consistency across these built environment variables, and both the Cronbach’s alpha (0.8548) and Composite reliability coefficient (0.8552) suggest the walkability is a reliable construct.

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\(^1\) Entropy = \(\sum_{i=1}^{k} (p_i \log p_i)/\log k\), where \(p_i\) is the proportion of each land-use type, \(k\) is the number of land use types. Five types including park, residential, education, industrial, and commercial were used to calculate this index.

\(^2\) Connected node ratio = \# street intersections with 3 or more valences divided by \# street intersections with 3 or more valences plus \# culs-de-sacs.
Our construct of walkability is based on the walkability index developed in previous studies (Frank et al., 2010; Frank et al., 2005; Kuzmyak et al., 2006; Manaugh and El-Geneidy, 2011). Most of the indices include the 4Ds of the built environment: density, diversity, design (focusing on street connectivity), and destination accessibility. In the latest national walkability index developed by US EPA (Thomas and Reyes, 2021), proximity to transit stops was included as a measure of walkability. Our walkability factor also includes these built environment dimensions. It is worth noting that there are pros and cons to use the walkability index. On the one hand, because some of the built environment variables are highly correlated, walkability as a composite measure helps alleviate the multicollinearity problem in the model. It also makes our final model parsimonious. On the other hand, the composite metric may make policy interpretations of model results ambiguous. We also tested models using individual built environment variables, but none of

Fig. 3. Spatial distribution of the sampling neighborhoods.
them are significantly associated with the perceived discrimination. This finding is consistent with the result while we use walkability in the model.

In addition to the built environment, we measured social environment using measures on neighborhood cohesion. These measures, adapted from Sampson et al. (1997), include “People around my neighborhood are willing to help their neighbors”; “This is a close-knit neighborhood”; “People in this neighborhood can be trusted”; “People in this neighborhood generally don’t get along”; and “People in this neighborhood do not share the same values”. These statements were coded using a five-point Likert scale from “strongly disagree” (1) to “strongly agree” (5). Internal consistency among these statements was high (Cronbach’s alpha = 0.8434; Composite reliability = 0.8426). In our structural equation model, we specified social environment as a latent variable measured by these five items. A description of all measured variables is in Table 3.

### Table 2

Factor loadings of walkability.

| Built environment variables | Loadings |
|-----------------------------|----------|
| Population density          | 0.910    |
| % commercial land use       | 0.727    |
| Entropy index               | 0.659    |
| Connected node ratio        | 0.624    |
| Bus stop density            | 0.916    |
| Train station density       | 0.724    |

### Table 3

Summary statistics of all variables.

| Code or Unit | Mean | SD | Min | Max |
|--------------|------|----|-----|-----|
| **Race and Socio-demographics** | | |
| Race | | |
| White | 1 = yes; 0 = otherwise | 0.74 | 0.44 | 0 | 1 |
| Asian | 1 = yes; 0 = otherwise | 0.16 | 0.36 | 0 | 1 |
| Others | 1 = yes; 0 = otherwise | 0.11 | 0.31 | 0 | 1 |
| Age | 1 = Aged 18–24; 2 = 25–34; 3 = 35–44; 4 = 45–54; 5 = 55–64; 6 = 65–74; 7 = 75–84; 8 = 85 or older | 3.34 | 1.58 | 1 | 8 |
| Female | 1 = yes; 0 = otherwise | 0.53 | 0.50 | 0 | 1 |
| Married | 1 = yes; 0 = otherwise | 0.61 | 0.49 | 0 | 1 |
| Education level | 1 = Did not go to school; 2 = Some primary school; 3 = Some secondary school; 4 = Finished primary school; 5 = Finished secondary school; 6 = Completed post-school certificate or diploma; 7 = Completed bachelor degree qualification; 8 = Completed post-graduation qualification | 6.47 | 1.22 | 2 | 8 |
| Income | 1 = Negative or Zero Income; 2 = $1 - $9,999 per year; 3 = $10,000 - $19,999 per year; 4 = $20,000 - $29,999 per year; 5 = $30,000 - $39,999 per year; 6 = $40,000 - $49,999 per year; 7 = $50,000 - $59,999 per year; 8 = $60,000 - $79,999 per year; 9 = $80,000 - $99,999 per year; 10 = $100,000 - $124,999 per year; 11 = $125,000 - $149,999 per year; 12 = $150,000 - $199,999 per year; 13 = $200,000 or more per year | 8.71 | 2.94 | 1 | 13 |
| **Perceived discrimination** | | |
| Have you been treated with less respect than other people? | 1 = Definitely not; 2 = Probably not; 3 = Might or might not; 4 = Probably yes; 5 = Definitely yes | 2.07 | 1.10 | 1 | 5 |
| **Neighborhood environment** | | |
| Residential location | | |
| Inner city | 1 = yes; 0 = otherwise | 0.09 | 0.29 | 0 | 1 |
| Inner suburb | 1 = yes; 0 = otherwise | 0.27 | 0.44 | 0 | 1 |
| Middle suburb | 1 = yes; 0 = otherwise | 0.27 | 0.44 | 0 | 1 |
| Outer suburb | 1 = yes; 0 = otherwise | 0.37 | 0.48 | 0 | 1 |
| Walkability | Factor score | 1.09 | 1.26 | -1.27 | 5.56 |
| Percentage of vegetation | Percentage | 15% | 12% | 0% | 91% |
| Social environment | | |
| People are willing to help their neighbors. | 1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neither agree nor disagree; 4 = Somewhat agree; 5 = Strongly agree | 3.52 | 0.99 | 1 | 5 |
| This is a close-knit neighborhood. | | |
| People do not share the same values. | | |
| People can be trusted. | | |
| People don’t get along with each other. | | |
| Changes in walking behavior | | |
| −2 = A lot less; −1 = A little less; 0 = Unchanged; 1 = A little more; 2 = A lot more | 0.36 | 1.26 | -2 | 2 |
3.4. Modeling methods

We applied the structural equation model (SEM) approach to examine the pathways established in the conceptual framework (Fig. 1). The approach enabled us to investigate the direct effects of race, socio-demographics, and neighborhood environment on changes in walking behavior and the mediating effects of perceived discrimination. Because the two endogenous variables, perceived discrimination and changes in walking behavior, are ordered-response variables, we applied the WLSMV (weighted least squares mean and variance adjusted) estimation method in Mplus 8.3.

4. Results and discussion

The SEM results are presented in Table 5. The model fit indices, CFI (0.928) and RMSEA (0.035), indicate that the models are acceptable. In particular, Comparative Fit Index (CFI) ranges from 0 and 1, with a larger value being a better fit. Its cutoff value for a good fit was initially set as 0.90 but Hu and Bentler (1999) recommended using 0.95. The recommended cutoff values for Root Mean Square Error of Approximation (RMSEA) range from 0.05 to 0.10 and a value smaller than 0.08 is generally considered an acceptable fit (Hooper et al., 2008). Further, model results indicate that the standardized loadings for five indicators assessing the social environment are of sufficient magnitude, ranging from 0.666 to 0.750 (see Table 4).

4.1. Race, perceived discrimination, and walking behavior

As shown in Table 5, perceived discrimination was significantly and negatively associated with changes in walking behavior. Those who perceived they were treated with less respect than other people after the outbreak of COVID-19 were more likely to reduce their walking frequency during the pandemic.

The SEM also shows the roles of race in perceived discrimination and changes in walking behavior. Asian respondents perceived a higher level of discrimination than White respondents (statistically significant) and those of other races (marginally significant),

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3 This is applicable when the scale is a lot less or a little less. If the scale is a little more or a lot more, the negative coefficient should be interpreted as less likely to increase their frequency. For simplicity, we will not make this distinction in the remainder of the paper.
suggesting rising racial discrimination against Asians in the pandemic. Asians may be subject to verbal attacks simply because of wearing a mask while walking on the street during the pandemic (Wang et al., 2020). A nationwide survey conducted by the Australian Lowy Institute in November 2020 showed that nearly 20% of Chinese Australians reported that they were physically threatened or attacked during the pandemic because of their Chinese heritage (Kassam and Hsu, 2021). Australia has a historical anti-Asian legacy and institutionalized White supremacy. Anti-Asian prejudice was already a social concern in Australia before the pandemic (Tan et al., 2021). This issue, however, has been exacerbated during the pandemic, as a result of the economic fallout of the pandemic and an increase of biased political and media attacks towards China (Tan et al., 2021). Furthermore, the pandemic may invoke the historical stereotype of Asians as unassimilable foreigners, leading to additional racism (Tan et al., 2021). The surge of anti-Asian sentiment during the COVID-19 pandemic is not unique; similar cases have happened in previous pandemics or epidemics, including the 2003 SARS epidemic (Eichelberger, 2007; Mohr, 2004).

In addition, we tested the indirect effect of race on changes in walking behavior through perceived discrimination. The coefficient of White was positive and significant ($\beta = 0.012; p = 0.043$), suggesting that perceived discrimination explains race differences in changes of walking frequency in the pandemic. It demonstrates that during the pandemic, the daily travel of the Asian population was negatively affected by perceived discrimination. Furthermore, we found that Asian respondents were more likely to reduce their walking frequency in the pandemic than their White counterparts. That is, besides perceived discrimination, there are other unknown mechanisms that explain the relationship between race and changes in walking behavior. We speculate that Asians may be more risk averse to the COVID-19 and hence are less likely to expose themselves to others including walking on the sidewalk and in the parks (for the sake of social distancing). Furthermore, Asians usually prefer to walk together either with their family members or friends, and this is probably reinforced during the pandemic period due to the increased anti-Asian sentiment. However, the Greater Melbourne stage-4 lockdown policy permits only one person per household to go shopping and one other person to accompany them for outdoor exercise activities, restricting Asians from walking for more shopping and exercise.

Walking is an active travel mode and provides opportunities to contact nature and people. The critical role of walking in boosting mental health has been recognized in previous research (Ma and Ye, 2022). Based on the survey data of this study, we also found that more walking was significantly associated with better mental wellbeing ($r = 0.145, p = 0.000$) and a lower level of depression ($r = -0.051, p = 0.092$) in the pandemic. Walking, therefore, provides an important means to buffer the psychological impact of the pandemic. However, the anti-Asian discrimination limits Asians from gaining mental health benefits associated with more walking. This helps explain the findings of recent studies that Asians had lower levels of mental health and higher levels of depression and anxiety in the pandemic (Cheah et al., 2020; Misra et al., 2020; Wu et al., 2020). More importantly, our study suggests another type of inequity in walking during the pandemic – racism-induced inequity.

Besides walking behavior, we also modeled the effects of racism on other types of travel behavior (including transit and car trips). However, the effects of perceived discrimination on changes in driving, bus, and train trips were not significant in the models. We have attached these model results in the Appendix (Table A1-A3). Several reasons might explain the insignificant results. First, drivers are less likely to be exposed to the outdoor environment and hence racial attacks than pedestrians. Drivers may also feel more secured inside their vehicles than pedestrians. Second, because transit is a public means of transportation, passengers’ behavior on the bus or train is seen by other passengers and security cameras. Those who seek to commit racial offences on transit will face fines or arrest. However, random racial attacks are more common among pedestrians. Moreover, transit trips have plummeted for all population groups in the pandemic. Other reasons such as working from home policies and health-related concerns may obscure the effect of perceived discrimination on transit decline. Walking trips, on the other hand, have grown as a result of the pandemic. During the lockdown, people walked to local destinations as well as for exercise. Therefore, the impact of racism on changes in walking behavior is more likely to be recorded than that on changes in transit use.

Furthermore, as shown in Table A1, Asians were more likely to increase driving trips than Whites. Although all the groups increased walking, Asians increased less than others. These findings imply that Asians may have disproportionately increased driving at the expense of walking as a result of the racism.

4.2. Role of neighborhood environment in perceived discrimination and walking behavior

We examined the roles of the neighborhood environment in perceived discrimination and changes in walking behavior. First, we did not find a significant correlation between the built environment and perceived discrimination. Residential location indicators (e.g., inner-city vs. suburbs), for example, were not associated with perceived discrimination, although we assumed that a higher level of racial diversity in the inner city might lead to more racial discrimination incidents in the inner city than the suburbs. Furthermore, neither neighborhood walkability nor vegetation cover was associated with perceived discrimination. Although previous studies have shown that open spaces such as green spaces and parks may play a positive role in promoting understanding and bridging racial gaps (Hoffman, 2019; Shinew et al., 2017), this may not apply well to the COVID-19 pandemic. Social distancing reduces visitors’ interactions in community parks and other green spaces. The Asian stigma resulting from the pandemic may also limit the interactions between Asians and other racial groups.

Neighborhood social cohesion was significantly and negatively associated with perceived discrimination. That is, living in an inclusive and friendly neighborhood may help reduce perceived discrimination. This is probably because a socially cohesive

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4 This variable was measured by using the World Health Organization- Five Well-Being Index (WHO-5).

5 This variable was measured by using the Kessler Psychological Distress Scale (K6).
neighborhood helps enhance mutual understanding and trust across people with different cultural, religious, racial, and linguistic backgrounds, promoting mutual respect and tolerance of diversity. It is also possible that racial minorities may have more of a sense of belonging in a socially cohesive neighborhood, reducing the feelings of being excluded and the level of perceived discrimination in the pandemic.

Neighborhood social cohesion was associated with more walking in the pandemic, though this relationship is marginally significant. This finding implies that a cohesive neighborhood environment is beneficial for improving walking in the pandemic. In addition, several studies (Liu and Painter, 2012; Shin, 2017; Smart, 2015) have suggested that living in ethnic enclave neighborhoods has a significant effect on the travel behavior of an ethnic group. We tested whether or not Asians live in Asian enclaves is significant for their walking behavior change in the pandemic. Because we failed to reject the null hypothesis, we did not include the variable in the model.

The SEM results also reveal interesting findings regarding the association between the built environment and changes in walking behavior. Compared with those who lived in the inner city, people who lived in the middle and outer suburbs were significantly less likely to increase their walking frequency in the pandemic. While the inner suburb variable was also negatively associated with changes in walking, this relationship was not statistically significant, suggesting that there were no significant differences in walking behavior change between residents in the inner city and inner suburbs. Like other major capital cities in Australia, residential density

### Table A1
SEM model results for driving trips.

| Perceived discrimination | More driving trips during the pandemic |
|--------------------------|----------------------------------------|
| Coef.  | P > z      | Coef.  | P > z      |
| Direct effects | Direct effects |

**Race**

|            |            |            |
|------------|------------|------------|
| Asian (reference) |            |            |
| White       | 0.141      | 0.141      |
| Others      | 0.069      | 0.069      |

**Neighborhood environment**

|            |            |            |
|------------|------------|------------|
| Inner city (reference) |            |            |
| Middle suburb | 0.001      | 0.987      |
| Outer suburb | 0.016      | 0.816      |
| Vegetation Cover | 0.001      | 0.000      |

**Socio-demographics**

|            |            |            |
|------------|------------|------------|
| Age        | 0.220      | 0.000      |
| Female     | 0.006      | 0.858      |
| Married    | 0.021      | 0.540      |
| Education level | 0.009      | 0.794      |
| Income     | 0.091      | 0.012      |

### Table A2
SEM model results for bus trips.

| Perceived discrimination | More bus trips during the pandemic |
|--------------------------|-----------------------------------|
| Coef.  | P > z      | Coef.  | P > z      |
| Direct effects | Direct effects |

**Race**

|            |            |            |
|------------|------------|------------|
| Asian (reference) |            |            |
| White       | 0.141      | 0.000      |
| Others      | 0.069      | 0.077      |

**Neighborhood environment**

|            |            |            |
|------------|------------|------------|
| Inner city (reference) |            |            |
| Middle suburb | 0.007      | 0.935      |
| Outer suburb | 0.066      | 0.504      |
| Vegetation Cover | 0.001      | 0.987      |
| Social environment | 0.234      | 0.000      |

**Socio-demographics**

|            |            |            |
|------------|------------|------------|
| Age        | 0.220      | 0.000      |
| Female     | 0.006      | 0.858      |
| Married    | 0.021      | 0.540      |
| Education level | 0.009      | 0.793      |
| Income     | 0.091      | 0.012      |
of the Melbourne metropolitan area gradually goes down from the inner city to the outer suburbs. Its inner city and inner suburbs have relatively higher levels of walkability than middle and outer suburbs.

4.3. Other factors associated with perceived discrimination and walking behavior

While not the major interest of this study, the SEM also illustrates the roles of socio-demographics in perceived discrimination and changes in walking behavior. Younger adults and lower-income people were more likely to perceive discrimination. Older adults and people with relatively lower levels of education and income were less likely to increase their walking frequency during the pandemic.

5. Conclusions

In this study we examined the impacts of racial discrimination on walking behavior and the role of the neighborhood environment in alleviating the racial stigma in the COVID-19 pandemic. We applied structural equation models to a survey dataset of residents of the Melbourne metropolitan area collected during a pandemic lockdown. This study contributes to the literature by improving our understanding of the relationship between racism and travel behavior. It also provides new insights into policies that aim to improve transport equity and social justice.

First, we found that people’s walking behavior in the pandemic was significantly and negatively impacted by perceived discrimination. In particular, while walking activities increased during the pandemic, Asians were less likely to have more walking activities than Whites. Furthermore, perceived discrimination was a non-trivial factor that discouraged Asians from engaging in more walking activities. We argue that Asians had a different walking behavior pattern from Whites because they experienced double impacts of the pandemic and racial discrimination. Walking provides an important means for combating mental stress and boosting psychological wellbeing. The disparity in changes in walking behavior because of perceived discrimination is probably one reason that explains lower levels of mental health and higher levels of depression and anxiety among Asians in the pandemic. While several recent studies (Cheah et al., 2020; Cheng, 2020) have linked racism with mental stress during the COVID-19 pandemic, our study highlights travel behavior change due to racism may be one of the reasons.

The second major finding was the relationship between the neighborhood environment and perceived discrimination. We found that the social environment was significantly and negatively associated with perceived discrimination. People who lived in a socially cohesive community perceived less discrimination in the pandemic. Our study provides new evidence for the relationship between social cohesion and perceived discrimination in the context of a public health crisis.

These findings have policy implications. First, previous policies on transport equity have less focus on racial discrimination. This study highlights the important role of racial discrimination in transport inequity. Furthermore, the impact of racial discrimination may become more prominent in a pandemic. To improve the community and urban resilience, it is necessary to devise policies that address racism issues. One way to mitigate racial discrimination, as revealed in our study and also previous studies, is to strengthen neighborhood social cohesion. A socially cohesive neighborhood helps reduce prejudices and promote communications and understandings among different racial groups. To improve neighborhood social cohesion, both top-down policy interventions and bottom-up local initiatives are needed. First, local governments need to engage and empower community residents to participate in important decision makings and planning process of their neighborhoods, and social cohesion should be embedded as an important performance indicator of local governments. Second, community-level organizations (e.g., community centers) and leadership can be also key to advance
social cohesion. During the Melbourne lockdown, some neighborhoods have initiated community care programs that provide free takeaway meals and groceries to help families heavily impacted by the pandemic. Third, residents in the community may also play an important role in building social cohesion. We have seen various types of innovative bottom-up initiatives in Melbourne during this pandemic. For example, residents living on the same street or in the same neighborhood created Facebook groups to share interesting things, ask for help or offer help to neighbors, and cheer each other up. Finally, we also need tailoring supporting programs that target the discriminated populations in a pandemic to help them cope with the adversity and bounce back from the shock. One such example is the Stop AAPI Hate initiative, which assists Asian Americans and Pacific Islanders in the US to address the anti-Asian racism incidents in the COVID-19 pandemic, and supports community-level efforts in improving safety and justice.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

See Table A1-A3.

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