This is the published version:

King, Tania Louise, Bentley, Rebecca Jodie, Thornton, Lukar Ezra and Kavanagh, Anne Marie 2015, Does the presence and mix of destinations influence walking and physical activity?, *International journal of behavioral nutrition and physical activity*, vol. 12, no. 1, pp. 1-12.

Available from Deakin Research Online:

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Does the presence and mix of destinations influence walking and physical activity?

Tania Louise King1*, Rebecca Jodie Bentley1, Lukar Ezra Thornton2 and Anne Marie Kavanagh1

Abstract

Background: Local destinations have previously been shown to be associated with higher levels of both physical activity and walking, but little is known about how specific destinations are related to activity. This study examined associations between types and mix of destinations and both walking frequency and physical activity.

Method: The sample consisted of 2349 residents of 50 urban areas in metropolitan Melbourne, Australia. Using geographic information systems, seven types of destinations were examined within three network buffers (400 meters (m), 800 m and 1200 m) of respondents’ homes. Multilevel logistic regression was used to estimate effects of each destination type separately, as well as destination mix (variety) on: 1) likelihood of walking for at least 10 min ≥ 4/week; 2) likelihood of being sufficiently physically active. All models were adjusted for potential confounders.

Results: All destination types were positively associated with walking frequency, and physical activity sufficiently at 1200 m. For the 800 m buffer, all destinations except transport stops and sports facilities were significantly associated with physical activity, while all except sports facilities were associated with walking frequency; at 400 m, cafés/takeaway food stores and transport stops were associated with walking frequency and physical activity sufficiently, and sports facilities were also associated with walking frequency. Strongest associations for both outcomes were observed for community resources and small food stores at both 800 m and 1200 m. For all buffer distances, greater mix was associated with greater walking frequency. Inclusion of walking in physical activity models led to attenuation of associations.

Conclusions: The results of this analysis indicate that there is an association between destinations and both walking frequency and physical activity sufficiently, and that this relationship varies by destination type. It is also clear that greater mix of destinations positively predicts walking frequency and physical activity sufficiently.

Keywords: Walking, Physical activity, Geographic information systems, Multilevel analysis, Built environment, Destinations

Background

Physical inactivity is known to be associated with a range of serious health risks and diseases [1]; indeed it has been claimed that together with smoking, physical inactivity may be the most significant, modifiable determinant of all-cause mortality and chronic morbidity [1, 2]. Walking is the most common form of physical activity in both Australia [3–5] and elsewhere such as the United States [1, 6, 7], and is known to offer many potential health benefits [8–10].

The local neighbourhood is an important setting for physical activity, and there is mounting evidence that elements of the built environment are associated with walking and physical activity [11–15]. Destinations are an increasing focus of investigation: if destinations can encourage more active travel, such as walking in neighbourhoods, it is possible that residents may be more likely to meet their physical activity needs.
accessibility to destinations is known to have positive associations with walking behaviours [16–20]. These associations between destinations, and walking, have been reported in many countries including Australia [18, 21, 22], Belgium [23], Japan [24], the US [25–28], New Zealand [29] and the United Kingdom [30] on a number of indicators including: the presence of destinations within walking distance of home [18, 27, 31], proximity to destinations [26, 32, 33], and density of destinations [27].

Other researchers have observed that walking is more likely to be influenced by the type and mix of destinations than simply the presence of destinations [21]. Most previous studies of destination mix (often referred to as number of types of businesses/destinations) indicate that increased destination mix is associated with increased walking [18, 32, 34, 35], however there are some contrary results, with destination mix having no effect on walking levels among older Australians (aged 65–84 years) [19].

There are some important limitations with the current evidence-base that this study seeks to address. First, it is unclear exactly what types of destinations produce the greatest effects on physical activity and walking, as few previous studies have looked at multiple, specific destinations. Other researchers have observed that most studies have focused on 'commercial destinations' such as shops and services [36], or destinations that are intuitively associated with walking [37]. Non-commercial destinations such as community resources (e.g., libraries) may also influence neighbourhood physical activity and walking in adults. Second, it is difficult to judge the distance that residents might be prepared to walk to access destinations as most previous studies have used just one, sometimes two catchments/buffer distances. A recent review highlighted the need for research into potential threshold distances at which destinations might encourage walking [38]. Thirdly, there is a need for more sophisticated methods of measuring destination mix. While some authors have examined the mix of destinations, they have typically relied on relatively simple measures of the number of unique types of destinations within a specific distance of respondents' homes [18, 37]. However, some destinations such as transport stops may be more common than others (e.g., supermarkets). Mix may be better captured by a measure that accounts for the relative frequency of the different types of destinations. We are aware of only one study that has considered how access to multiple destinations of a particular type might influence walking more than access to only one [29], however this incorporated mix into a broader index of destination accessibility.

To address some of the identified gaps in previous methods this study sought to:

1. Identify which destinations (of supermarkets, small food stores, transport stops and stations, community resources, cafes and takeaway food stores, sporting facilities, and educational facilities) within residential neighbourhoods are associated with walking for 10 min or more, at least four times a week.
2. Assess the extent to which the hypothesized associations between destinations and walking frequency translate into associations between destinations and physical activity sufficiency (given that walking is the most common form of physical activity).
3. Understand how the mix of destinations is associated with walking frequency and physical activity, where mix takes into account the relative frequency of different destination types across the sample.

Methods

Datasets

Individual-level data

Individual-level variables from the Victorian Lifestyle and Neighbourhood Environment Study (VicLANES) dataset were used. The methods used in the VicLANES study and details of the sample have been documented previously [39–42].

In brief, VicLANES was a large, multilevel study conducted in 2003–2004 across the 21 innermost local government areas (LGAs) in Melbourne, Australia. Fifty census collection districts (known as CCDs, at the time of the study these were the smallest geographic unit of measurement used by the Australian Bureau of Statistics (ABS)) were randomly selected from the sample of LGAs stratified by a household measure of low income (<$400/week). Surveys about physical activity were sent to 4005 residents 18 years and over, who were randomly selected from the electoral roll (voting is compulsory for all Australians over 18 years, and it is estimated that 97.7% of those eligible to vote are enrolled) [43]. A 58.7% valid completion rate was achieved, with 2349 residents returning a completed survey.

Destination data

Destination information came from the VicLANES environmental audit, and publicly available spatial datasets such as Ausway™ and PSMA. The VicLANES environmental audit has been reported previously [41], and involved a team of trained auditors collecting detailed information on different food shops selling food for consumption within the home.

The destination variables included in the dataset were classified into seven categories: educational facilities, café/takeaway stores, transport stops, supermarkets, sports facilities, community resources, small food stores. Data for supermarkets, small food stores and café/takeaway stores came from VicLANES. Destinations included in the
education, community resource and sport layers came from Ausway**, producers of Australian street directories. Transport data came from Metlink (the public transport operator for the Victorian State Government), and PSMA (Public Service Mapping Authority). A summary of these variables is contained in Additional file 1: Table S1.

The **community resources** category included the following: maternal and child health centres; community health centres; community centres; post offices; places of worship; cinemas, theatres and art galleries; public libraries. Based on advice from Ausway** that ‘core’ community services such as schools, post offices, community services were complete, but non-core services such as restaurants were not, we chose ‘community resource’ features that were deemed both ‘core’ and a potential destination for walking.

The **education** category was comprised of the following Ausway** derived points of interest: schools (primary and secondary); childcare and kindergartens; other places of education such as universities and TAFE** campuses. Public transport** contained tram and bus stops and railway stations. A supermarket was defined as a food store selling fresh produce with four or more checkouts. The **small food store** category included: fruit and vegetable shops; butchers and fishmongers; bakeries; small grocery stores (less than 4 checkouts); convenience store (corner store, fuel station with convenience food); specialty shops (such as delicatessens, health food stores, ethnic food stores). Café and restaurant/takeaway excluded restaurants that were only dine-in premises. The **sports** category contained information on all swimming pools and tennis courts in the study areas.

**Outcome measures**

**Walking frequency**

A closed response question asked respondents about their frequency of walking for at least 10 min in the previous month. Respondents were required to tick one of six response categories: never; about once or twice, about once a week, about 2–3 times a week, about 4–5 times a week, every day. Responses were dichotomized to ‘less than four times a week’ (<4/week) and ‘four times a week or more’ (>4/week). The cut-off response category (4–5 times a week) for this dichotomization closely approximates the number of sessions (at least five) recommended to meet physical activity sufficiency [1, 44].

**Physical activity sufficiency**

Using items from the Active Australia Survey, respondents were asked to indicate the frequency and duration of their participation in walking, vigorous physical activity, moderate physical activity, vigorous garden or yard work. These items were then used to produce a measure of overall physical activity sufficiency. The Active Australia Questionnaire has been used in national surveys, and demonstrates very good reliability and validity [44].

Australian and international guidelines recommend that a person participate in at least 30 min of moderate to vigorous intensity activity most days of the week, for a total of at least 150 min of activity [1, 44, 45]. According to the Active Australia Survey guidelines, physical activity sufficiency for health can be measured in two ways [44]: 1) measured as total time engaged in physical activity (at least 150 min for sufficiency); 2) measured as the total time across the total number of sessions (at least 150 min across at least five sessions). We have chosen to use the combined measure of time and number of sessions (at least 150 min of at least moderate intensity activity across at least five session week) [46, 47], because it matches guidelines for physical activity sufficiency.

In accordance with the Active Australia Survey administration and implementation guidelines, VicLANES responses were converted to total amount of time (minutes) engaged in each activity, and summed, with vigorous activity weighted by a factor of two [4, 44]. Respondents were then categorized in one of two categories: those reporting less than 150 min of at least moderate activity were classified as ‘insufficiently active’; those with at least 150 min of at least moderate activity across at least five sessions were classified as ‘sufficiently physically active’.

**Spatial analysis: buffer generation and network analysis**

Geographic information systems (GIS) software was used to generate network buffers at 400 m, 800 m, 1200 m distances around each individual’s residence. Network analysis was then conducted to identify the number of destinations within each distance of respondents’ homes. Destination counts were then extracted from GIS, and formed the exposure variables, described henceforth.

**Exposure variables: destinations and destination mix**

The destination counts arising from the spatial analysis were positively skewed and were therefore modelled as ordinal variables. In the first instance we sought to model the exposure variables as tertiles, as tertiles enable exploration of a dose response gradient. Due to the way that responses clustered around certain values, the use of tertiles was not always possible (e.g., where responses were highly dominated by 0). In such instances variables were modelled as binary exposures (refer to Table 1 for list of exposure variable types and cut points).

**Exposure variables: derivation of mix measure**

This study used a measure of destination mix that accounted for variation in the frequency of different destination types. The chief reason for measuring mix in
### Table 1 Summary of exposure variables

<table>
<thead>
<tr>
<th>Exposure variable</th>
<th>Buffer (m)</th>
<th>Mean (SD)</th>
<th>Range</th>
<th>Median (IQR)</th>
<th>Variable type (modelled as)</th>
<th>Category cut points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>400</td>
<td>0.59 (0.97)</td>
<td>0–7</td>
<td>0 (0, 1)</td>
<td>Binary</td>
<td>0</td>
</tr>
<tr>
<td>Education</td>
<td>800</td>
<td>2.31 (2.31)</td>
<td>0–14</td>
<td>2 (1, 3)</td>
<td>Tertile</td>
<td>0–1</td>
</tr>
<tr>
<td>Education</td>
<td>1200</td>
<td>5.05 (3.77)</td>
<td>0–20</td>
<td>4 (2, 7)</td>
<td>Tertile</td>
<td>0–3</td>
</tr>
<tr>
<td>Café/takeaway stores</td>
<td>400</td>
<td>0.71 (1.59)</td>
<td>0–16</td>
<td>0 (0, 1)</td>
<td>Binary</td>
<td>0</td>
</tr>
<tr>
<td>Café/takeaway stores</td>
<td>800</td>
<td>4.69 (8.55)</td>
<td>0–56</td>
<td>1 (0, 5)</td>
<td>Tertile</td>
<td>0</td>
</tr>
<tr>
<td>Café/takeaway stores</td>
<td>1200</td>
<td>12.14 (15.66)</td>
<td>0–73</td>
<td>7 (1, 16)</td>
<td>Tertile</td>
<td>0–3</td>
</tr>
<tr>
<td>Transport stops</td>
<td>400</td>
<td>3.5 (3.13)</td>
<td>0–18</td>
<td>3 (1, 6)</td>
<td>Tertile</td>
<td>0</td>
</tr>
<tr>
<td>Transport stops</td>
<td>800</td>
<td>13.42 (8.09)</td>
<td>0–45</td>
<td>13 (8, 18)</td>
<td>Tertile</td>
<td>0–10</td>
</tr>
<tr>
<td>Transport stops</td>
<td>1200</td>
<td>29.75 (15.78)</td>
<td>0–81</td>
<td>27 (19, 39)</td>
<td>Tertile</td>
<td>0–23</td>
</tr>
<tr>
<td>Supermarkets</td>
<td>400</td>
<td>0.05 (0.29)</td>
<td>0–2</td>
<td>0 (0, 0)</td>
<td>Binary</td>
<td>0</td>
</tr>
<tr>
<td>Supermarkets</td>
<td>800</td>
<td>0.31 (0.67)</td>
<td>0–4</td>
<td>0 (0, 0)</td>
<td>Binary</td>
<td>0</td>
</tr>
<tr>
<td>Supermarkets</td>
<td>1200</td>
<td>0.80 (1.02)</td>
<td>0–4</td>
<td>0 (0, 1)</td>
<td>Binary</td>
<td>0</td>
</tr>
<tr>
<td>Sports facilities</td>
<td>400</td>
<td>0.20 (0.52)</td>
<td>0–4</td>
<td>0 (0, 0)</td>
<td>Binary</td>
<td>0</td>
</tr>
<tr>
<td>Sports facilities</td>
<td>800</td>
<td>0.78 (1.05)</td>
<td>0–5</td>
<td>0 (0, 1)</td>
<td>Binary</td>
<td>0</td>
</tr>
<tr>
<td>Sports facilities</td>
<td>1200</td>
<td>1.72 (1.56)</td>
<td>0–8</td>
<td>2 (0, 3)</td>
<td>Tertile</td>
<td>0–1–2</td>
</tr>
<tr>
<td>Community resources</td>
<td>400</td>
<td>0.51 (1.01)</td>
<td>0–5</td>
<td>0 (0, 1)</td>
<td>Binary</td>
<td>0</td>
</tr>
<tr>
<td>Community resources</td>
<td>800</td>
<td>2.54 (2.97)</td>
<td>0–15</td>
<td>2 (0, 4)</td>
<td>Tertile</td>
<td>0–1</td>
</tr>
<tr>
<td>Community resources</td>
<td>1200</td>
<td>5.39 (5.56)</td>
<td>0–31</td>
<td>5 (1, 9)</td>
<td>Tertile</td>
<td>0–2</td>
</tr>
<tr>
<td>Small food stores</td>
<td>400</td>
<td>0.71 (1.70)</td>
<td>0–17</td>
<td>0 (0, 1)</td>
<td>Binary</td>
<td>0</td>
</tr>
<tr>
<td>Small food stores</td>
<td>800</td>
<td>4.23 (6.13)</td>
<td>0–55</td>
<td>2 (0, 5)</td>
<td>Tertile</td>
<td>0</td>
</tr>
<tr>
<td>Small food stores</td>
<td>1200</td>
<td>10.48 (11.28)</td>
<td>0–58</td>
<td>7 (2, 15)</td>
<td>Tertile</td>
<td>0–3</td>
</tr>
</tbody>
</table>

This way was to equalize the effect of different destination types, particularly those more widespread than others. Some destinations (i.e., transport destinations) were abundant, whereas others (i.e., supermarkets) were sparse. The mix measure was constructed by:

1. Calculating the median number of destinations for each type at each buffer distance
2. For each person, assigning a value of 1 when the number of destinations were above the median and 0 if equal or below the median for each type
3. Summing each of the values derived in point (2), to create a mix variable with a range of 0–7

**Confounders**

Based on the literature, several covariates were included in the models as potential confounders because they are likely to be related to walking frequency, physical activity and destination distribution. These were: age (18–24 years, 25–34 years, 35–44 years, 45–54 years, 55–64 years, 64 years and over); sex; country of birth (born in Australia, born in a country other than Australia); education (bachelor degree or higher, diploma, vocational training, and no post school qualification); household type (single adult-no children, single adult with children, two or more adults-no children, two or more adults with children); disability/injury that prevents exercise (yes, no); area disadvantage (least disadvantaged, mid disadvantaged and most disadvantaged); and dominant household occupation (professional, white-collar employee, blue-collar employee, not in labour force). The ‘not in labour force’ category included retirees, students, unemployed, those not looking for, or unable to work.

**Statistical analysis**

All statistical analyses were conducted in Stata IC 10.0. Pregnant women (n = 22) were excluded because their walking and physical activity levels may have been altered by their pregnancy status. One CCD from just outside the central business district (CBD) of Melbourne was omitted from the final analysis (n = 14) as this CCD’s catchment area encapsulated almost the entire CBD, and the number of features/destinations contained in its catchment was irregularly high. Missing data for the other variables ranged from 0.5–2.9%, with the exception of the disability item, for which missing data amounted to 6.1%. Eight respondents for whom there was no walking data were excluded, resulting in an analytical sample of 2305 respondents, and 49 CCDs for the walking analysis. For the physical activity analysis, data