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Identifying destination distances that support walking trips in local neighborhoods

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ABSTRACT

When examining associations between local destinations and walking it is common to count local destinations using street network buffers measured at various distances to mitigate spatial data aggregation issues caused by scale and the Modifiable Areal Unit Problem. However, it remains unclear whether a particular buffer size is preferred since large buffers may mask important effects whilst small buffers may not accurately represent a neighborhood area. Furthermore, the use of various buffer distances in measuring destination counts does not yield specific information on distances where destinations could be placed in order to increase levels of walking. This paper extends current methods to address these issues by using a new method to define network buffers to identify threshold distances for walking to seven destination types using multilevel models. Donut-buffers are introduced as a method of counting destinations between distances of 401 m–800 m and 801 m–1200 m which are compared to standard network buffers at distances of 400 m, 800 m and 1200 m respectively. We found that destinations within 401 m–800 m could be responsible for associations found at a network buffer of 1200 m. Specifically, the odds of walking increased when local food outlets including supermarkets, cafés/takeaway stores, and small food stores, were located within 401 m–800 m but not 801 m–1200 m, suggesting that these destinations encourage walking when placed at 401 m–800 m away. Consequently we argue that donut-buffers offer greater specificity than standard network buffers for geographic measurement of destinations. This warrants further investigation to inform urban policy guidelines for designing walkable environments.

1. Introduction

The quantity, mix and proximity of destinations located in neighborhoods are strongly associated with walking (Ewing and Cervero, 2010) with a growing number of longitudinal studies confirming these findings (Giles-Corti et al., 2013; Hirsch

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et al., 2014; Knuiman et al., 2014). Decisions made by urban planners and designers about the proximity, mix and quantity of local destinations therefore play a key role in determining whether or not residents have the opportunity to, and are likely, to walk.

A best practice approach to designing pedestrian-friendly communities, has been to create the '400 m neighborhood' (Western Australian Planning Commission, 2000), which locates shops and services within a 'walkable' distance of 5 minutes from residences (i.e., 400 m). However, there is little evidence to support whether this threshold optimizes levels of walking. Indeed, there is evidence that people walk further than 400 m to access local destinations (Agrawal and Schimek, 2007; McCormack et al., 2008; Yang and Diez-Roux, 2012). Moreover, some studies find that people are willing to walk further than commonly used catchment-buffers of 400 m for buses and 800 m for trains (O'Sullivan and Morrall, 1996; El-Geneidy et al., 2014). Other studies use public participation or soft geographic information system (softGIS) techniques to record information on distances to destinations nominated by survey participants, with findings again suggesting that people are willing to travel longer distances than the aforementioned planning guidelines (Salonen et al., 2014). To develop urban design guidelines that support sufficient levels of walking that promote health, evidence is needed about what constitutes a threshold walkable distance to increase walking to local destinations.

To address this problem, active living researchers have recommended and used a variety of approaches to define the availability of local destinations, with density and availability of destinations measured using different network buffer sizes around study participants' homes, ranging from 400 m to 1600 m in size; and, within different administrative units such as Census Collection Districts (CCDs), census tracts, and suburbs (Brownson et al., 2009). These different approaches have contributed to different effect sizes when evaluating built environment associations with walking and can lead to bias in the measurement of spatial proximity measures (Duncan et al., 2014).

The correspondence between differing exposure effect and buffer definitions and buffer sizes is related to the measurement of the built environment in terms of scale, and spatial and social patterning which are related to both the Modifiable Areal Unit Problem (MAUP) and the Uncertain Geographic Context Problem (UCGP) (Openshaw, 1984; Kwan and Weber, 2008). When measuring spatial factors, the MAUP considers how much area (i.e., scale) is included and its configuration or zoning. The UCGP considers the discord between abstract buffer definitions of areas representing neighborhoods and areas individuals frequent in their daily lives known as 'life- or activity-spaces' (Kwan and Weber, 2008). To mitigate some of these issues, the definition of buffers and buffer distances should match the outcome of interest (Clark and Scott, 2014). However, despite advances in GPS technology few papers have investigated scale and differing buffer definitions when measuring the built environment for defining land uses such as destinations and their association with walking (Boruff et al., 2012; Hirsch et al., 2014).

In understanding appropriate scales for defining buffers, three problems are associated with current approaches to studying distances to destinations. First, in comparing network buffers of different sizes (e.g., ≤ 400 m, ≤ 800 m, ≤ 1200 m) researchers fail to consider that smaller buffers are contained within larger buffers (see Fig. 1), making it difficult to disentangle whether destinations in close proximity or those measured further away are driving the observed associations with walking outcomes. Second, a growing number of studies have considered the independent influence of destination quantity, mix and proximity (Cerin et al., 2007; McCormack et al., 2008; King et al., 2015) on walking using network buffer measures without establishing threshold distances for walking. These approaches provide limited guidance to planners about the distance from homes to local destinations that may influence health (Giles-Corti et al., 2005). Finally, it is unlikely that any one destination alone encourages walking. Rather, it is the combination of destinations that increases walking (Sallis et al., 2009).

This paper seeks to address this gap in the literature by using a novel approach to evaluate how the built environment around people's homes changes with increasing distance and how these changes influence walking. To inform future urban design guidelines on proximity to destinations, we measured access to destinations based on what we have called 'donut-buffers', i.e., incremental network buffers around study participants' homes with destinations counted between distances of 401–800 m and 801–1200 m. We compared this new method with standard network buffer approaches that count the number of destinations based on street network buffers of 400 m, 800 m and 1200 m respectively. This paper extends the work of (King et al., 2015) in examining the relationship between destinations and the frequency of walking trips.

2. Methods

2.1. Survey data

Data from the cross-sectional multilevel Victorian Lifestyle and Neighborhood Environment Study (VicLANES) were used. Data were collected in 2003 from 2349 participants aged over 18 years. Survey methods have been described elsewhere (Kavanagh et al., 2005; King et al., 2006). Data were collected on 21 inner local government areas (LGAs) and 50 CCDs located within 20 km of the Melbourne Central Business District. Using 2002 data from the Australian Bureau of Statistics, CCDs were randomly selected and stratified according to the proportion of low income households (< $400/week). At the time of survey, CCDs were the smallest geographic unit of measurement covering approximately 200 dwellings (Australian Bureau of Statistics, 2001). Participants in these areas were randomly selected from the electoral roll which includes 97.5% of people eligible to vote (Australian Electoral Commission, 2005) and for this reason all survey respondents were successfully