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Effects of buffer size and shape on associations between the built environment and energy balance

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ABSTRACT

Uncertainty in the relevant spatial context may drive heterogeneity in findings on the built environment and energy balance. To estimate the effect of this uncertainty, we conducted a sensitivity analysis defining intersection and business densities and counts within different buffer sizes and shapes on associations with self-reported walking and body mass index. Linear regression results indicated that the scale and shape of buffers influenced study results and may partly explain the inconsistent findings in the built environment and energy balance literature.

1. Introduction

High levels of obesity are a pressing problem, costing the United States approximately $147 billion in healthcare costs annually (Finkelstein et al., 2009). Additionally, physical inactivity contributes to approximately 6.7% of the burden of disease due to coronary heart disease and 8.3% of the burden of disease due to type 2 diabetes, and causes 10.8% of premature mortality in the United States, on par with smoking in terms of preventable causes of disease (Lee et al., 2012). Individual lifestyle choices undoubtedly influence obesity and physical activity; however, researchers have begun exploring contextual influences on these energy balance outcomes as predicted by ecological models of behavior change (Sallis et al., 2006, Moos, 1976, Sherwood and Jeffery, 2000, Sallis and Owen, 1997). Specifically, factors of the built environment, such as nearby destinations to walk to or well-connected streets that create efficient routes to reach those destinations, may create opportunities for higher levels of walking and lower levels of obesity (Handy, 2005). This approach is predicated on the concept that there is a relevant spatial context at which the environment affects an individual's behavior. This paper explores how different definitions of spatial contexts can influence analytical results.

The findings in research on the built environment over the last decade have been inconsistent. A recent review of the literature of the built environment and obesity revealed that about half of reported associations were null and there was very little between-study similarity in methods, preventing pooled estimates of effects

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(Feng et al., 2010). This heterogeneity in methodology across studies is an impediment to understanding the totality of the evidence of the built environment's impact on obesity.

Early studies defined an individual's exposure to the built environment based on administrative boundaries, such as counties, census tracts, or ZIP codes (Rundle et al., 2007, Mujahid et al., 2008, Lopez, 2007, Joshu et al., 2008, James et al., 2013, Ewing et al., 2006). A recent literature review by Leal and Chaix (2011) on the relationship between geographic environments and cardiometabolic risk factors revealed that 73% of studies reviewed relied on administrative boundaries to assess exposure. While these measures are convenient because statistics are often gathered using administrative boundaries and privacy legislation often prohibits the release of datasets that include personal identifying information, there is an implicit assumption that administratively defined neighborhoods are an accurate and adequate representation of a "true" causally relevant spatial context (Foster and Hipp, 2011). Approaches that disregard the spatial unit in which study participants live and work may introduce significant measurement error and may decrease statistical power of contextual analyses and bias effect estimates (Spielman and Yoo, 2009). For instance, an individual may live on the edge of a census tract and may actually spend the majority of his/her time in an adjacent tract. Additionally, the use of administrative boundaries to define the built environment can lead to the modifiable areal unit problem, where the results of statistical analysis may differ according to the scale and pattern of the areal units chosen (Flowerdew et al., 2008, Flowerdew, 2011, Haynes et al., 2007).

In order to measure a closer approximation of an individual's relevant spatial context, a method has emerged to define the built environment context through spatial units around geocoded home addresses. This method involves creating an area around a given distance from a home address. Researchers then use this spatial unit, an individual residence-based buffer, to define built environment measures for each individual. There are two dominant approaches to creating these measures of the built environment (Fig. 1). Radial, or Euclidean, buffers are created by drawing a straight line out a given distance from a home address creating a circle that is used to define the built environment (Berke et al., 2007, Rutt and Coleman, 2005, Nelson et al., 2006). While radial buffers may theoretically be more representative of the built environment that may influence behavior compared to administrative boundaries due to the issues outlined above, radial buffers may be less likely to represent the "true" relevant spatial context in areas with natural features such as bodies of water or built features such as railways or poorly connected roads. In these situations, areas within the radial buffer may be included in the calculation of built environment measures but may actually not be accessible by the study participant (Oliver et al., 2007). An alternative approach is the line-based network buffer, where a line is traced a given distance from the home address via the street network (Forsyth et al., 2012). Small buffers (e.g., of 50 m) are created around these lines to create a polygon of the traversable area within a given distance of the home address via the road network (Oliver et al., 2007). Line-based network buffers are thought to provide a more accurate representation of spatial context that would influence walking (Oliver et al., 2007, Boruff et al., 2012). The previously mentioned literature review by Leal and Chaix found that in studies that used buffers, 65% focused on radial buffers while the rest used a line-based network buffer approach. In the reviewed literature, the radius of circular buffers varied in area from 100 to 4800 m, while network buffers varied between 640 and 2000 m (Leal and Chaix, 2011).

Within each buffer, accessibility of walking destinations and street connectivity have been linked to walking (Handy, 2005, Sallis et al., 2012). It is hypothesized that accessibility of destinations provides opportunities for routine walking. As a measure of accessible destinations, counts or densities of businesses within a buffer have been used (Troped et al., 2013). Street connectivity could have influences on energy balance, as more connected street networks represent shorter distances between desintations and likely more dense neighborhoods conducive to walking (Berrigan et al., 2010). Intersection counts within a buffer are a common measure of street connectivity, which is defined as the directness

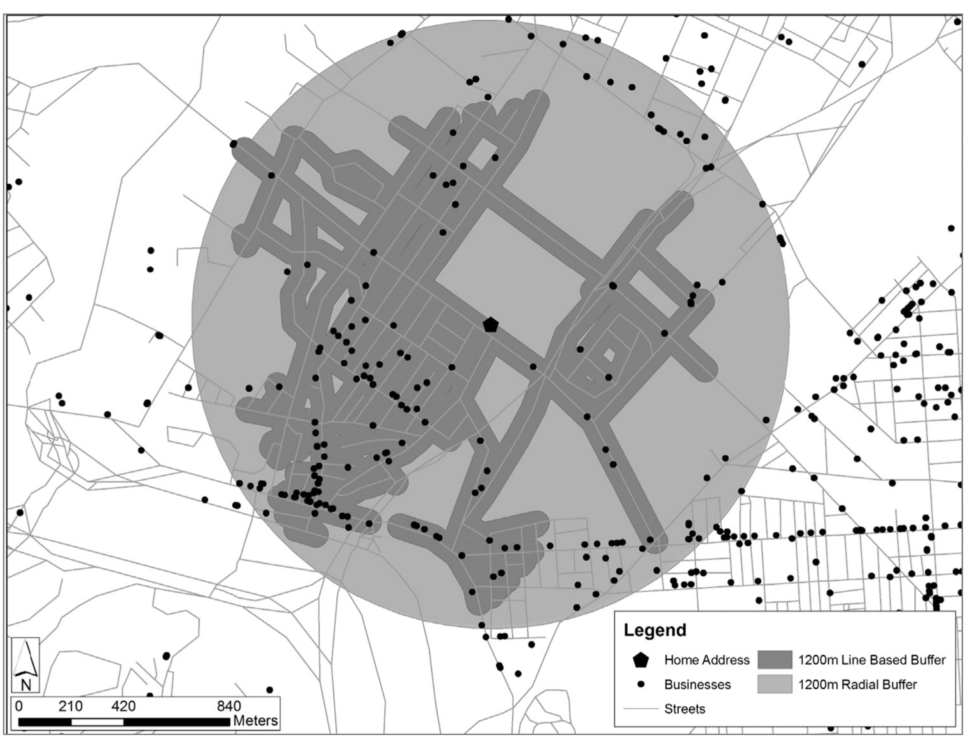

Fig. 1. Example of a radial buffer and line-based buffer with business addresses.