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Disentangling the relative influence of built and socioeconomic environments on walking: The contribution of areas homogenous along exposures of interest

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ABSTRACT

The geography of small areas has important implications for studying the contextual determinants of health because of potential errors when measuring ecologic exposures and estimating their effects on health. In this paper, we present an approach for designing homogeneous zones optimising the spatial distribution of an area-level exposure, active living potential (ALP), based on data collected in Montreal, Canada. The objectives are to (1) assess and compare variation in walking behaviours between these purposefully designed zones and between standard administrative units, census tracts; and (2) disentangle the relative influence of ALP and area-level socioeconomic conditions on walking using the alternative geographies. Zones were designed by statistically classifying smallest census areas (disseminations areas) into seven categories of exposure similar along three indicators of ALP: population density, land use mix, and geographic accessibility to services. Mapping of categories resulted in the delineation of zones characterised by one of seven levels of ALP. A sample of 2716 adults aged ≥45 years was geocoded and cross-classified in 270 zones and 112 census tracts. Individuals reported on minutes and motives of walking and provided socioeconomic information. Data were analysed using cross-classified multilevel models. Variation in utilitarian walking was larger across the purposefully defined zones than across census tracts. Total walking varied significantly between census tracts only. Greater ALP was associated with more utilitarian walking but with less recreational walking. Higher socioeconomic position in census tracts was positively associated with total, utilitarian, and recreational walking. The soundness of standard administrative units for measuring ecologic exposure and their associations with health should be considered prior to conducting analyses. The added value of different approaches for understanding how place relates to health remains to be established and should be the focus of further investigations.

Introduction

The geography of small area units has important implications for studying the contextual determinants of health because it is likely to influence the measurement of ecologic exposures (area-level characteristics) and the estimation of their effects on health (Cockings & Martin, 2005; Flowerdew, Manley, & Sabel, 2008; Haynes, Daras, Reading, & Jones, 2007; Haynes, Jones, Reading, Daras, & Emond, 2008; Oliver & Hayes, 2007; Stafford, Duke-Williams, & Shelton, 2008). The prevailing '*one-size fits all*' approach to defining small areas using standard administrative spatial units may therefore be '*too simplistic*' (Stafford et al., 2008). The most appropriate geography may be specific to the epidemiological outcome of interest (Chaix, Rosvall, Lynch, & Merlo, 2006; Cummins, Macintyre, Davidson, & Ellaway, 2005; Galea & Ahern, 2006; Gauvin, Robitaille, Riva, McLaren, Dassa, & Potvin, 2007; Stafford et al., 2008) and should be considered prior to conducting analyses (Flowerdew et al., 2008).

In this paper, we present an approach for designing homogeneous zones optimising the spatial distribution of a specific area-level exposure, active living potential, previously shown to be associated with a specific health indicator, walking. We then assess and compare the extent of variation in walking between these newly designed zones and between standard administrative units,

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i.e. census tracts, and estimate the relative influence of active living potential and area-level socioeconomic conditions on walking using alternative geographies.

Conceptual and methodological issues related to the operational definition of areas

In research on area effects on health, although the validity and reliability of measures of ecologic exposures are being perfected (Diez-Roux, 2008), defining "appropriate" small area units remains a challenge that gives rise to conceptual and empirical issues potentially challenging the construct and internal validity of studies (Osypuk & Galea, 2007).

Most often, areas are conceptualised as an ecological level of influence within which individuals are exposed to similar contextual conditions. Several authors have developed novel alternative approaches for defining small areas, using such methods as automated zone design (Cockings & Martin, 2005; Flowerdew et al., 2008; Haynes et al., 2007; Stafford et al., 2008) and combination of social, statistical, and spatial analysis methods (Browning & Cagney, 2003; Coulton, Korbin, Chan, & Su, 2001; Lebel, Pampalon, & Villeneuve, 2007; Popay, Thomas, Williams, Bennett, Gattrell, & Bostock, 2003). These efforts are far too few in comparison to studies defining areas using standard administrative units such as census tracts, wards, boroughs, or postcode sectors (Pickett & Pearl, 2001; Riva, Gauvin, & Barnett, 2007). These units are useful because they can easily be linked to data from censuses and other surveys that can be used to derive ecologic exposure measures. As administrative units are often designed to be homogeneous along socioeconomic dimensions, they may be appropriate for operationalising socioeconomic contexts (Ross, Tremblay, & Graham, 2004, p. 892). However, other contextual dimensions may not be optimally defined and measured within these "arbitrary" spatial units. As pointed out by Stafford and colleagues (2008; p. 892) " as estimates of between-area variation depend on the way that area boundaries are defined, the debate remains as to whether the effects are fully captured by the areas and aggregations used".

Heterogeneity of exposure within spatial units is problematic because it may lead to errors when measuring exposures and consequent non-differential classification of exposures. Two geographical "problems" are here at play: the modifiable area unit problem and spatial autocorrelation of geographic data. The modifiable areal unit problem refers to the fact that analytical results are sensitive to the definition of spatial units at which data are aggregated (Openshaw, 1984; Openshaw & Taylor, 1979). In other words, area effects may be observed only at certain scales, i.e. scales at which data are collected and aggregated and may vary or be absent when observed at other scales. Imposing arbitrary spatial units on the distribution of ecological exposures may lead to the delimitation of artificial spatial patterns and to errors in the measurement of ecologic exposures. In addition, using standard administrative units assumes that contextual conditions within one area are different from and influence health independently of the conditions of neighbouring areas, when in fact these conditions are autocorrelated (clustered) in space (Cliff & Ord, 1973). The variation of ecologic exposures may thus be smoothed out by the definition of area units used to measure them.

For any area effects to be detected there must be variation in the exposure being studied, i.e., the differences between areas must be maximised (Rothman & Greenland, 1998). If data are collected in contiguous and heterogeneous areas, variations in both characteristics of environments and health outcomes, and their association, may be misestimated. Indeed, stronger area effects on health have been observed in more homogeneous areas (Haynes et al., 2007; Haynes & Gale, 1999). Within-area homogeneity along the contextual conditions under examination therefore appears as important for minimising measurement error of exposures and non-differential exposure misclassification. This is crucial as these may influence the strength of contextual effect on health: effects may not be detected or may be spurious, therefore limiting the precision of research findings for informing public health and public policy actions to tackle social and geographical inequalities in health.

Establishing the homogeneity of small areas in relation to ecologic exposures hypothesised to be associated with health outcomes or health-related behaviour is therefore a major methodological consideration. Indeed, areas maximizing internal homogeneity of exposure while maximizing differences between them may better capture the extent of variation in health attributable to the different contexts wherein people live (Stafford et al., 2008).

Estimating area effects on walking: are census tracts appropriate spatial units?

In health and place research, understanding the environmental determinants of walking is receiving increasing attention. Practiced regularly, i.e. 30–60 min per day on most days of the week, walking translates into significant benefits for health (Haskell et al., 2007; United States Department of Health and Human Services [USDHHS] 1996). Walking is the most common type of physical activity across all age, income, and ethnic groups. As such, promoting regular walking is one strategy to address the public health burden of physical inactivity and weight-related problems (Haskell et al., 2007; Transportation Research Board and Institute of Medicine of the National Academies [TRB & IOM] 2005; USDHHS, 1996; World Cancer Research Fund/ American Institute for Cancer Research [WCRF/AICR] 2007).

Characteristics of the built and social environment of residential areas are being documented as important correlates of walking. Several studies report consistent associations between walking and higher residential/population density, proximity to non-residential destinations, greater land use mix, better road network connectivity, presence and accessibility of parks and open spaces, and safety (for a review of evidence, please see Saelens & Handy, 2008; TRB & IOM, 2005). Results of some studies suggest that environment characteristics are differently associated with motives for walking, i.e. utilitarian versus recreational walking (Frank, Engelke, & Schmid, 2003). Studies investigating socioeconomic contextual effects have reported contrasting findings (Fisher, Li, & Michael, 2004; Giles-Corti & Donovan, 2002; Gordon-Larsen, Nelson, & Beam, 2005; Miles, Panton, Jang, & Haymes, 2008; Ross, 2000; Rutt & Coleman, 2005).

Residential areas can thus be thought of as showing different levels of active living potential (ALP) (Gauvin et al., 2005), that is conditions of environments that encourage the likelihood of active living, i.e. integrating physical activity into daily routines, in individuals and populations (Active living research, http://www.activelivingresearch.org). Understanding the aetiological significance of small areas for walking is therefore essential for informing public health actions aiming at creating supportive environments for active living.

In a previous study set on the Island of Montreal, Canada, we assessed whether or not census tracts were appropriate spatial units for measuring the ALP of residential environments and for estimating the association between this exposure and walking behaviours (Riva, Apparicio, Gauvin, & Brodeur, 2008). Census tracts were selected because of extensive use of this spatial unit of analysis in current North American research on health and place. For doing so, we designed zones that were homogeneous along three indicators of ALP, population density, land use mix, and geographic accessibility to selected proximity services. These zones