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Using experienced activity spaces to measure foodscape exposure

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ABSTRACT

Researchers are increasingly interested in understanding how food environments influence eating behavior and weight-related health outcomes. Little is known about the dose–response relationship between foodscapes and behavior or weight, with measures of food exposure having mainly focused on fixed anchor points including residential neighborhoods, schools, or workplaces. Recent calls have been made to extend the consideration of environmental influences beyond local neighborhoods and also to shift away from place-based, to people-based, measures of exposure. This report presents analyses of novel activity-space measures of exposure to foodscapes, combining travel survey data with food store locations in Montreal and Quebec City, Canada. The resulting individual activity-space experienced foodscape exposure measures differ from traditional residential-based measures, and show variations by age and income levels. Furthermore, these activity-space exposure measures once modeled, can be used as predictors of health outcomes. Hence, travel surveys can be used to estimate environmental exposure for health survey participants.

1. Introduction

The current obesity epidemic witnessed in most industrialized and developing countries has increased the interest in food accessibility (McKinnon et al., 2009). Recent changes in our foodscapes (Burgoine et al., 2009; Cohen, 2008) — that is, increasing exposure to food, food cues (Arredondo et al., 2009; Scully et al., 2009), and available calories (Bauer et al., 2009; Dumanovsky et al., 2009) in a world of plenty (Levenstein, 1993) — are considered as obesogenic contributors to the epidemic (Cohen, 2008).

However, little is known about the dose–response relationship between exposure to food and dietary intake. This lack of knowledge is in part due to the complex and intertwined spatial, social, and temporal dimensions involved in people–place interactions, making it difficult to adequately measure exposure – in this specific case, exposure to foodscapes or elements thereof – and furthermore unravel the potential biopsychosocial pathways that relate environmental risk conditions to health behavior and health outcomes (Daniel et al., 2008).

Studies have shown exposure to food cues resulting in increased dopamine secretion, itself associated to desire, craving, and motivation to act (Cohen, 2008; Volkow, 2007), whereas accessibility to retail food sources or exposure to food cues (Fedoroff et al., 1997; Halford et al., 2004) was further linked to deprivation (Moore and Diez Roux, 2006), outlining possible pathways of social health inequality observed in overweight, obesity, and cardiovascular disease.

Socio-economic status (SES) gradients have been demonstrated in relation to accessibility to various retail food store types, mainly fast-food outlets (Block et al, 2004; Cummins et al., 2005; Graddy, 1997; Macdonald et al., 2007), stores providing fruit and vegetables (Morland et al., 2002; Shohaimi et al., 2004; Timperio et al., 2008), or to other metrics of retail food store ratios or indexes (Mehta and Chang, 2008; Sharkey et al., 2009; Spence et al., 2009). Studies on the association between food environments and food purchasing (Turrell et al., 2002), diet (Evans et al., 2008; Moore et al., 2009; Morland et al., 2002; Shohaimi et al., 2004; Timperio et al., 2008), or harder outcomes like body mass index (BMI) (Currie et al., 2009; Holsten, 2009; Maddock, 2004; Mehta and Chang, 2008; Spence et al., 2009), cardiovascular outcomes (Alter, 2005; Morgenstern et al., 2009), or mortality (Daniel et al., submitted for publication) show mixed findings. As an example, associations between accessibility to fast-food outlets or other metrics evaluating the variety and proportion of unhealthful on healthful food sources in the environment (Mehta and Chang, 2008; Spence et al., 2009) and fast food consumption

Abbreviations: ASEF, Activity space experienced foodscape; REF, Residence experienced foodscape; FFO, Fast-food outlet; FSR, Full-service restaurant; BMI, Body mass index; SES, Socio-economic status

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or higher BMI have been found positive (Currie et al., 2009; Inagami et al., 2009; Maddock, 2004; Moore et al., 2009; Thornton et al., 2009), negative (Crawford et al., 2008; Frank et al., 2006; Jeffery et al., 2006; Pearce et al., 2009), or null (Burdette and Whitaker, 2004; Simmons et al., 2005; Thornton et al., 2009). Recent evidence further indicates intermediary effects of individual-level psychosocial dimensions of mastery (Paquet et al.), reward sensitivity (Paquet et al., 2010), or car ownership (Inagami et al., 2009) in the relation between availability and consumption of high-caloric food or BMI, Similarly, socio-economic disparities in the relation between objective and subjective perceptions of food environments may be partly responsible for SES differences in food purchase and food consumption behavior (Giskes et al., 2007; Inglis et al., 2008). Inconsistent findings on the relation between food environment and health behavior and outcomes might be linked to strong individual-level variations in the dose–response relationship, but also to inconsistent or incomplete measures of exposure to food environs itself. This is an emerging field for which methodological advances in the measurement of exposure to environs is strongly required.

Clearly, there is a need to develop measures of exposure to foodscapes (Glanz et al., 2005; McKinnon et al., 2009) in order to better understand (i) what characteristics of our food environments influence eating behavior and (ii) by which mechanisms exposure to food sources and food cues translate into food-related health behavior.

Exposure or accessibility to retail food sources is generally measured in terms of distance to the closest or *n* closest food stores (Apparicio et al., 2008, 2007), as an areal density, or as a food store to population ratio (Maddock, 2004).

Most of the studies that have been published on food exposure use "fixed" spatial units, with point-based anchors like place of residence, schools or work places, or area-based anchors like census or other socio-political units. This is a problem because people get exposed to a variety of environments as they move to accomplish their activities, and consideration of the multiplicity of exposures is currently lacking.

The nature of our home and its surroundings is certainly central to our interaction with our environments, and much of the current work on health and place relies on the underlying principle that our home location is central to the mechanisms that link place to health. Consequently, and because some geographical information on place of residence is generally available for the data being analysed, the vast majority of studies evaluating environmental determinants of health use home-based measures of social and physical environments. This has led to a large body of research trying to establish appropriate spatial definitions of this home "environment", in terms of spatial limits (Gauvin et al., 2007; Lebel et al., 2007; Riva et al., 2008), and similarly, in terms of using the appropriate scale of observation (Gregorio et al., 2005; Johnston et al., 2004) to establish measures of neighborhood characteristics. However, although most people do have a fixed home address for which some XY coordinates – with varying levels of precision and accuracy (Bonner et al., 2003; Krieger et al., 2002, 2001; Yang et al., 2004) – can be obtained, an important proportion of people extend their activity space beyond their local home neighborhood. Limiting contextual measures to the local residential space has been referred to as a potential "local trap" (Cummins, 2007) or "residential trap" (Chaix, 2009).

People's mobility can be considered at different time scales, two central ones being the life-cycle scale and the daily scale. At the life-cycle scale, mobility is associated with one's residential history or travel history (Clark and Onaka, 1983; Oppermann, 1995). Although residential moves are in general infrequent, choices of residential location, resulting from a set of opportunities and constraints heavily condition subsequent daily mobility (Scheiner, 2006). The nature and characteristics of daily mobility (number of trips, length of trips, mode of transportation used), linked to the necessity to fulfill activities, can be predicted in part by individual-level factors (age, occupation, income, educational attainment, car ownership, psychosocial dimensions), household-level factors (partner and/or children in household, car to drivers license ratio), and place of residence or land-use characteristics (land use mix, density of destinations, proximity to work places, etc.). Beyond predicting mobility itself, we hypothesize that these same variables are capable of predicting the types of places (Stovel and Bolan, 2004) people get exposed to, and consequently the nature of exposure to food environments.

Building on Hägerstrand's seminal work on space-time travel geography, a series of measures of space-time prisms have been developed (Kitamura et al., 1981; Kostyniuk and Kitamura, 1982) and mainly applied to the measure of accessibility (Kwan and Hong, 1998; Lenntorp, 1976; Miller, 1991). Potential activity spaces represent areas that can theoretically be reached considering a set of constraints including time, transportation, and obligations to fulfill certain activities at fixed locations and times (Kwan and Hong, 1998). Similarly, activity spaces refer to the portion of the environment actually used by an individual to fulfill activities and travel between visited locations (Golledge and Stimson, 1997). Different ways of measuring activity spaces have been used to represent the individuals' place experience (Axhausen, 2005; Schönfelder and Axhausen, 2002). The consideration of space-time geography and related operational activity spaces can be applied to integrate experienced or potential exposure to environmental conditions in health research (Rainham et al., 2009). This approach is relevant to evaluating "neighborhood" effects on health as it allows integrating the variety of locations or anchor points to which people are exposed, thereby allowing to consider people's set of interactions with various places (Saarloos et al., 2009; Sherman et al., 2005). Although studies have assessed neighborhood-level food exposure for out-of-home activity places such as workplace or schools, few have yet tried to evaluate exposure to foodscapes while accounting for daily mobility. One study in Minnesota analysed density of fast-food outlets around both place of residence and place of work in relation to fast-food consumption and BMI (Jeffery et al., 2006), and found a significant inverse relation between density of restaurants – either fast-food outlets or full service restaurants – around work place and BMI among men, whereas no association was found with fast-food consumption, either for men or women, at home place or at work place. Bertrand et al. (2008) have used census-tract car-ownership rates to establish accessibility measures in Montreal, using either 500 m buffers for households not owning a car and 3 km buffers for households with a car. Another noticeable work has used individual and place-specific, distance traveled, models to estimate individual- and place-specific accessibility to the retail food environment in Montreal (Páez et al., 2010). Finally, travel surveys have been used before to derive space-time sensitive exposure measures to air pollution (Klepeis et al., 2001; Marquez et al., 2001), vehicle crash injuries (Beck et al., 2007), or outdoor media advertising (Kam and Lau, 2005).

As researchers focus efforts to understand the contextual determinants of health behavior and health outcomes, there is an important need for improving and extending measures of exposure to activity places. This paper establishes measures of exposure to experienced environs, using exposure to foodscape as an empirical application. Based on a space-time perspective and using the concept of activity spaces, travel survey data was combined with data on the location of retail food stores in Montreal and Quebec City, allowing novel measures of activity space experienced foodscapes (ASEF) to be developed and compared with traditional measures of residence experienced