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Multilevel built environment features and individual odds of overweight and obesity in Utah

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ABSTRACT

Based on the data from the Behavioral Risk Factor Surveillance System (BRFSS) in 2007, 2009 and 2011 in Utah, this research uses multilevel modeling (MLM) to examine the associations between neighborhood built environments and individual odds of overweight and obesity after controlling for individual risk factors. The BRFSS data include information on 21,961 individuals geocoded to zip code areas. Individual variables include BMI (body mass index) and socio-demographic attributes such as age, gender, race, marital status, education attainment, employment status, and whether an individual smokes. Neighborhood built environment factors measured at both zip code and county levels include street connectivity, walk score, distance to parks, and food environment. Two additional neighborhood variables, namely the poverty rate and urbanicity, are also included as control variables. MLM results show that at the zip code level, poverty rate and distance to parks are significant and negative covariates of the odds of overweight and obesity; and at the county level, food environment is the sole significant factor with stronger fast food presence linked to higher odds of overweight and obesity. These findings suggest that obesity risk factors lie in multiple neighborhood levels and built environment features need to be defined at a neighborhood size relevant to residents' activity space.

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Introduction

Obesity is a lifestyle-based risk factor of a wide range of health problems, including heart disease, stroke, diabetes and some of the leading causes of preventable death, and has become a major public health concern in the United States in recent decades (Zhang, Lu, & Holt, 2011). It is now adding a shocking $190 billion to the annual national healthcare from obesity-related conditions; this amount constitutes almost 21% of the total healthcare costs (Begley, 2012). Although Utah is among the states with the lowest obesity rates in the U.S., the estimated prevalence of overweight and obesity is over 60% according to the BEE Well Utah (2014).

According to the energy balance theory, an individual's excessive body weight results from a positive balance where total energy intake such as food and drink cumulatively exceeds total energy expenditure including physical activity (Schoeller, 2009). The obesogenic environment thesis suggests that obesity-preventive factors include exposure to a healthy food environment that promotes healthier dietary choices and built environments that encourage physical activities (Hill & Peters 1998; Swinburn, Egger, & Raza 1999). Built environment is broadly defined as "human-formed, developed, or structured areas" (CDC, 2005), and includes walkable urban form, places to be physically active, and attractive and safe environment (Casey, Elliott, & Glanz, 2008; Lovasi, Hutson, Guerra, & Neckerman, 2009; Miles, Panton, Jang, & Haymes, 2008). In this paper, food environment is also considered part of the built environment.

Multilevel modeling is commonly used in research on obesity etiology by incorporating both individual-level risk factors and neighborhood characteristics (Wang, Wen, & Xu, 2013; Wen & Maloney, 2011). Individual variables are often obtained directly from surveys while built environment factors are measured at some neighborhood level(s) from various data sources. One challenge is to determine what constitutes an appropriate neighborhood scale or size in defining the built environment. For example, in analyzing overweight risks, Gordon. Nelson, & Rage (2006) used an 8-km radius around one's residence as a reasonable range to define available physical activity facilities. Rutt and Coleman (2005) defined neighborhood as a 0.25-mile radius around each person's

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residence to examine the association between mixed land use and BMI. In examining the impact of urban sprawl index on obesity rate, Ewing, Schmid, Killingsworth, Zlot, and Raudenbush (2003) used the county level and Kelly-Schwartz, Stockard, Doyle, and Schlossberg (2004) chose primary metropolitan statistical areas (PMSA). Yamada et al. (2012) examined walkability in Salt Lake City in multiple geographic scales such as census tracts, block group and street network buffers. Other studies in this field also employed smaller area units such as census tracts (Wen & Maloney, 2011) and zip code areas (Wang, Guo, & McLafferty, 2012) to define neighborhoods, depending mainly on what geographic identifiers were available in the research data. The wide variability in neighborhood size without a fair justification of its choice may lead to questions of stability and reliability of research results, an issue related to the modifiable areal unit problem (MAUP) (Fotheringham & Wong, 1991).

More recently, several MLM-based studies examined the issue of appropriate area unit(s) for defining the neighborhood effect in public health. It is widely acknowledged that effective interventions on health behaviors and outcomes occur on multiple levels (Nader, Bradley, Houts, McRitchie, & O'Brien, 2008). Mobley, Kuo, and Andrews (2008) examined how contextual variables in four types of geographic areas (post code areas, primary care service areas, medical service study areas, and county) affected the use of mammography service, and found inconsistent results across the four levels. Another study offered some insights speculating that small local areas might reflect social support while a large area unit might reflect geo-political units and minorities' political influence (Kuo, Mobley, & Anselin, 2011). Wang et al. (2012) constructed a new level of geographic areas from zip code areas with comparable population size to examine the neighborhood effect when neighborhoods are defined in different sizes. Kwan (2012b) used a term “the uncertain geographic context problem (UGCoP)” to refer to unstable results derived from different delineations of contextual units, and went on to suggest that contextual units should be defined in a way that captures people's actual or potential activity spaces (Kwan, 2012a).

The current research continues this line of work to examine the neighborhood effects at both zip code and county levels on association of several built environment factors with individual odds of overweight and obesity. We seek to explore appropriate neighborhood units for a particular built environment factor in Utah.

Data and variable definitions

Individual-level data used in this study are from the Utah Behavioral Risk Factor Surveillance Survey (BRFSS) collected in 2007, 2009 and 2011 by the Utah Department of Health in conjunction with the CDC for assessing health conditions and risk in the non-institutionalized Utah adult population (18 years and older). The 2011 BRFSS data reflects a change in weighting methodology (raking) and the addition of cell phone only respondents while the 2007 and 2009 BRFSS were solely based on landline subject recruiting and data collection (http://www.cdc.gov/brfss/annual_data/annual_2011.htm). The BRFSS data (http://health.utah.gov/opha/OPHA_BRFSS.htm) contains rich information on individual socio-demographic characteristics, behavioral factors and health conditions with zip code provided for each respondent. After deleting a small amount of missing data, 21,961 observations are used in the research. Among these records, there are 9962 men and 11,999 women. Some zip code boundaries have changed over time, and a few zip codes are points. By checking the postal service website and other online sources, we were able to construct a unified GIS layer of 299 zip codes in 29 counties as shown in Fig. 1.

Descriptive statistics for the Utah residents in the study sample are shown in Table 1. More than 60% of the study participants are either overweight or obese and the prevalence of obesity in this sample is 24.2%. The majority of the residents are white. About 70% of the sample received college degree or above.

Body mass index (BMI) was calculated based on self-reported height and weight: BMI = mass (kg)/(height (m))^2. According to the CDC, an adult who has a BMI between 25 and 29.9 is considered overweight, while BMI of 30 or higher is obese (http://www.cdc.gov/obesity/adult/defining.html). Two levels of excessive weight were examined in this study, obesity ($\text{BMI} \geq 30$) and overweight plus obesity ($\text{BMI} \geq 25$). Socio-demographic variables including age (continuously measured), gender, race (whites versus non-whites), employment status (categorical), education level (college graduates versus below bachelor's degree), marital status (currently married or not) and smoking status (having smoked 100 cigarette or not) were controlled for in the analysis following previous work (Wen & Kowaleski-Jones, 2012). Age squared was added to further control for potential nonlinear age effect. Race/ethnicity was dichotomously measured into whites versus non-whites given the vast majority of the respondents were white. Employment status was characterized into several groups including “employed for wages” (as the reference category), “self-employed”, “out of work for more than one year”, “out of work for less than one year”, “homemaker”, “student”, and “retired.” Education was dichotomously measured given the threshold effect of college credentials on obesity prevention (Wen & Kowaleski-Jones, 2012).

Place-based socioeconomic status was captured by prevalence of residents living in poverty in a zip code area or a county according to the 2010 Census data. The built environment was captured by the following four variables constructed from multiple data sources.

Street connectivity was measured as the density of intersections, which are identified from the 2008 street centerline data in the ArcGIS 9.3 Data DVD by the ESRI (Aurbach 2010; Wang et al. 2013). Intersections with a starting or ending node of an edge or an intersection of 3-way or more edges were included in the connectivity index calculation. We first obtained the street connectivity in zip codes, and then aggregated to the county level. The aggregation takes population as the weight term such as

$$C_k = \sum_{i=1}^{n_k} P_i * C_i / P_k \qquad (1)$$

where C_k is the connectivity in county k, n_k is the number of zip code units in county k, P_i is the population of zip code i within county k, and P_k is the total population in county k. This aggregation process accounts for the uneven spatial distribution of population in a large areal unit such as county, and thus derives a more appropriate “population-adjusted” street connectivity index (Wang et al. 2013).

Walk score (http://www.walkscore.com/) is a measure of resource proximity and density based on the summed total of distance between a point of interest to nearby amenities (Brewster, Hurtado, Olson, & Yen, 2009). The algorithm is developed by the Front Seat Management (http://www.frontseat.org/) as a pending patent system, and produces a valid measure of walkability (Duncan, Aldstadt, Whalen, Melly, & Gortmaker, 2011). The algorithm uses location data of amenities such as restaurants, grocery stores, schools, parks, and movie theaters. The location data are sourced from Google, Education.com, Open Street Map, and Localeze. The Walk Score algorithm calculates a linear combination of the Euclidean distance from point of interest to the amenities. The weights in the linear combination are determined by facility type priority and a distance decay function (Front Seat, 2013). The Walk

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