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Relationship between urban sprawl and physical activity, obesity, and morbidity – Update and refinement ☆

Reid Ewing *, Gail Meakins [1], Shima Hamidi [2], Arthur C. Nelson [3]

Department of City and Metropolitan Planning, College of Architecture and Planning, 375 S 1530 E RM 235, Salt Lake City, UT 84112, USA

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ABSTRACT

Aims: This study aims to model multiple health outcomes and behaviors in terms of the updated, refined, and validated county compactness/sprawl measures.
Methods: Multiple health outcomes and behaviors are modeled using multi-level analysis.
Results: After controlling for observed confounding influences, both original and new compactness measures are negatively related to BMI, obesity, heart disease, high blood pressure, and diabetes. Indices are not significantly related to physical activity, perhaps because physical activity is not defined broadly to include active travel to work, shopping, and other destinations.
Conclusions: Developing urban and suburban areas in a more compact manner may have some salutary effect on obesity and chronic disease trends.

1. Introduction

The prevalence of adult obesity and overweight in the United States has risen significantly in the last 30 years (Khan et al., 2009). Data from the 2009–2010 National Health and Nutrition Examination Survey (NHANES) indicate that 36% of adults and 17% of youth are obese (Ogden et al., 2012). If these trends continue, more than 44% of people in the United States could be obese by the year 2030 (Levi et al., 2012). The rising prevalence of obesity presents serious long term challenges including the increased prevalence of chronic diseases resulting in decreased life expectancy, the potential for negative impacts on an individual's quality of life, the availability and cost of future health care, and the viability and productivity of future generations (Trogdon et al., 2008).

The fundamental cause of obesity and overweight is an imbalance between calories consumed and calories expended. While there are many influences impacting both weight and health, including genetics, socioeconomic status, race/ethnicity, and gender, two modifiable risk factors are unhealthy diets and physical inactivity, both of which have a spatial component (Black and Macinko, 2008; Trost et al., 2001, 2002). Physical inactivity has been identified as the fourth leading risk factor for global mortality causing an estimated 3.2 million deaths annually (WHO, 2012). It is commonly recognized that even a moderate amount of physical activity can result in significant health benefits (Centers for Disease Control and Prevention, 2009). Yet current research indicates that physical activity levels have declined, with many adults in the United States (43%) failing to meet the recommended physical activity requirements (CDC, 2009). In the last fifty years, activity levels have dropped for a variety of reasons including new technologies and automation that make our lives easier, television and computer use, and changes in the built environment that have led to sedentary life styles (Transportation Research Board and Institute of Medicine Committee on Physical Activity, Health, Transportation, and Land Use, 2005). Automobile use has substituted for active travel, and urban sprawl, the dominant development pattern in the United States, all but guarantees automobile dependence (Committee on Physical Activity, 2005).

In this article, we update a "sprawl index" first associated with obesity in 2003 (see Ewing et al., 2003b). The update is to 2010, using recent census and other data. The reason for updating is provide researchers and policy professionals with current data on sprawl, the earlier metrics now being more than decade old. Additionally, we develop a refined version of the same index that incorporates additional built environmental variables. The earlier metrics only covered two dimensions of sprawl, development density and street accessibility, while sprawl is often defined in terms of land use diversity (or lack thereof) and population and employment centering

* Corresponding author. Tel.: +1 801 581 8255.
E-mail addresses: ewing@arch.utah.edu (R. Ewing), g.meakins@gmail.com (G. Meakins), shima.hamidi@gmail.com (S. Hamidi), acnelson@utah.edu (A.C. Nelson).
[1] Tel.: +1 801 891 5179.
[2] Tel.: +1 801 581 8254.
[3] Tel.: +1 801 581 8253.

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(or lack thereof). The refined metrics cover all four dimensions. Principal component analysis is used to derive a density factor from five density variables, a mix factor from three variables, a centering factor from four variables, and a street accessibility factor from four variables. Finally, we apply the resulting indices to health data from the Behavioral Risk Factor Surveillance System (BRFSS) to see if reported relationships have changed over the decade since the first index was published. Checking for stability in relationships over time is the best way to check the validity and reliability of the 2003 results.

1.1. Literature

In 2003, Ewing et al. (2003b) first established a relationship between health behaviors, health outcomes, and a "county sprawl index," which became the most widely cited academic article in the Social Sciences as of late 2005, according to *Essential Science Indicators* (Reuters). After controlling for age, education, fruit and vegetable consumption, and other sociodemographic and behavioral covariates, they found that adults living in sprawling counties have higher body mass indices (BMIs) and are more likely to be obese (BMI > 30) than are their counterparts living in compact counties.

In the years since the original study, there has been a plethora of research studies in both planning and public health investigating the relationship between the built environment and health outcomes (Galvez et al., 2010, p. 202; Casey et al., 2011; Dunton et al., 2009; Finkelstein et al., 2005; Feng et al., 2010; Lachowycz and Jones, 2011; Papas et al., 2007; Withrow and Alter, 2010). Research has established statistically significant links between elements of the built environment and the risk of obesity (Booth et al., 2005; Papas et al., 2007; Feng et al., 2010), suggesting that some built environments may be more "obesogenic" than others (Black and Macinko, 2008).

Also since the original study, there have been numerous applications of the original county sprawl index (which has also been referred to as a compactness index, since compactness and sprawl anchor opposite ends of the same scale). The original sprawl index was made available to researchers who wished to explore the various costs and benefits of sprawl. Sprawl has now been linked, in one or another study, to physical inactivity, obesity, traffic fatalities, poor air quality, residential energy use, emergency response times, teenage driving, lack of social capital, private-vehicle commute distances and times, and coronary heart disease (Ewing et al., 2003a, 2003b, 2003c; Kelly-Schwartz et al., 2004; Sturm and Cohen, 2004; Cho et al., 2006; Doyle et al., 2006; Ewing et al., 2006; Kahn, 2006; Kim et al., 2006; Plantinga and Bernell, 2007; Ewing and Rong, 2008; Joshua et al., 2008; Stone, 2008; Trowbridge and McDonald, 2008; Fan and Song, 2009; McDonald and Trowbridge, 2009; Trowbridge et al., 2009; Lee et al., 2009; Nguyen, 2010; Stone et al., 2010; Schweitzer and Zhou, 2010; Gregson, 2011; Kostova, 2011; Zolnik, 2011; Holcombe and Williams, 2012; Griffin et al., 2012; James et al., 2013; Bereitschaft and Debbage, 2013).

1.2. Geographic scale

Since the 2003 study, most investigators have chosen to characterize the built environment of individuals at the neighborhood scale, whether in terms of census tracts, block groups, or small buffers around individuals' homes (starting with Frank et al., 2004). There has been an implicit assumption that walking distance from home is the operative scale at which the built environment affects physical activity, food availability, and ultimately weight. This is just an assumption. Adults spend most of their waking hours away from home. An estimated 30–40% of all trips are non-home-based. A sprawling metropolitan area produces long commutes, which cut into leisure time and hence physical activity. Access to healthy foods may be more difficult in sprawling environments. To our knowledge, only one study has compared the power of neighborhood and county environments as predictors of obesity (Joshua et al., 2008). While this study found that perceived neighborhood characteristics were more important than objectively measured county characteristics, it is likely that environmental factors at both scales are relevant for understanding obesity and physical activity. Better measures of macro-scale characteristics such as sprawl are needed to represent the broad settings that shape people's health-related activities.

2. Methods

2.1. Data and Measures

This study represents the built environment at the county scale rather than the smaller neighborhood scale. The main reason is expediency, since the health database used in this study, for reasons of confidentiality, only supplies geocodes for respondents by county, and then only for larger counties. However, the preceding discussion suggests that the county may be an appropriate scale for health research in an auto-oriented society like our own.

Health-related data come from the Behavioral Risk Factor Surveillance System (BRFSS), a telephone survey conducted by state health departments and managed by the Centers for Disease Control and Prevention (CDC). Over 350,000 adults are interviewed nationally each year to collect detailed information on health risk behaviors, preventive health practices, and health care access primarily related to chronic disease and injury.

We use a subsample of individuals for which county geocodes of residence are available for public use. Our data come from the Selected Metropolitan/Micropolitan Area Risk Trends (SMART) project which is populated with BRFSS data for metropolitan and micropolitan statistical areas with 500 or more respondents. We have included data for survey years 2007 through 2010. Different questions are asked in different survey years (all four years for most variables but only two years for some). This accounts for the different sample sizes for different variables in Table 1.

Our health outcome variables fall into three categories: weight status, physical activity, and chronic diseases. Weight status variables are calculated from self-reported height and weight. Body mass index (BMI) is a continuous variable defined as weight in kilograms divided by height in meters squared (kg/m^2). Obesity status is dichotomous, defined as having a BMI greater than or equal to 30.0. Weight status data are available for all four survey years.

One physical activity outcome is dichotomous: whether a respondent reported "any physical activity." The question reads: "During the past month, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?" This question is included in all four years of the BRFSS survey. The phrasing, particularly the reference to exercise, likely means the kind of active travel that occurs in compact areas will not be reported by respondents.

A second physical activity variable is continuous: minutes of moderate physical activity per week, which presumably includes the kind of walking we expect to see in compact areas. The 2003 study found that minutes of leisure-time walking were positively related to county compactness (Ewing et al., 2003b). This was the only physical activity variable with a significant relationship to compactness. More recent surveys have not asked about specific physical activities such as walking and bicycling, but instead have asked about moderate and vigorous physical activity generally. If any relationship is likely to show up between compactness and physical activity, it will be in minutes of moderate activity.[4] This is

[4] In BRFSS 2007 and 2009, respondents were asked if they engaged in moderate physical activities outside work for at least 10 min at a time. The specific question included in the 2007 and 2009 surveys was as follows: