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Relationship between multi-scale urban built environments and body mass index: A study of China

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ABSTRACT

Previous literature on the link between the built environment and body mass index (BMI) has paid very limited attention to the built environment at different geographical scales, the moderating effects of socioeconomic attributes, or developing countries, and has provided mixed evidence on some built-environment attributes. Thus, in this study, we explore the relationship between the built environment at both neighborhood and city scales and BMI, based on a sample of 4114 individuals from across China. Our findings show that (1) built-environment elements at both city and neighborhood scales are significant associated with BMI, although the city-scale built environment elements show more associations with BMI than the neighborhood scale; (2) the relationship between built-environment elements and BMI is moderated by individual socioeconomic attributes and behaviors; and (3) while at first, BMI decreases with increased city population density, it subsequently increases as density increases further. Thus, to prevent overweight and obesity, urban policymakers should consider the built environment at both neighborhood and city scales, give sufficient considerations to the heterogeneous effects of individual socioeconomic attributes and behaviors, highlight the reasonable size and density of cities and promote the jobs-housing balance.

1. Introduction

The global obesity epidemic caused by sedentary lifestyles and inadequate physical activity has increased in recent years, resulting in an upsurge in related research from various sociological and health perspectives (Kumanyika & Brownson, 2007; Phelan, Butryn, & Wing, 2007; World Health Organization, 2017). Moreover, overweight and obesity, which are known risk factors for type 2 diabetes, cardiovascular disease, et cetera (Colditz & Stein, 2007), are usually measured by body mass index (BMI), a numerical computation based on height and weight.

Urban geographers and urban planners have widely studied the relationship between the built environment and BMI in developed countries (Durand, Andalib, Dunton, Wolch, & Pentz, 2011; Garfinkel-Castro, Kim, Hamidi, & Ewing, 2017; King & Jacobson, 2017), and, from the viewpoint of smart growth, many researchers believe that residents of built environment areas with a compact development pattern have a lower BMI due to their higher likelihood of engaging in active travel and the consequent promotion of physical activity (King & Jacobson, 2017).

However, little is known about the situations in developing countries like China, which is facing the rapid growth of overweight and obesity rate and has different built environment attributes from west developed countries. China is the largest developing country in the world and has the largest population that accounts for one-fifth of the global population (Wang, Mi, Shan, Wang, & Ge, 2007). With the continuous increase in residents' income and the transformation of dietary structure in China, residents' BMI is showing a tendency to increase. From 2002 to 2012, the rate of overweight and of obesity in adults increased from 22.8% to 30.1% and from 7.1% to 11.9%, respectively (National Health and Family Planning Commission, 2016). On the other hand, the built environment in China differs greatly from that in developed countries. First, the population densities of many Chinese cities are very high and continue increasing. The average city population density was about nine times higher than the American cities' in 1995 (Kenworthy & Hu, 2002). According to the China City Statistical Yearbooks, the currently average city population density is twice as much as the 1990s'. Second, the transit is the dominant travel mode in most Chinese cities, compared to auto-dependent cities in the West (Gao & Kenworthy, 2017). Third, the pattern of residential development in Chinese cities is called the 'Superblock Model', which is characterized by single-use residential blocks surrounded by major

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arterial roads, long distances between daily destinations, even though development is dense (Calthorpe, 2016).

Previous studies have paid more attention to the built environment at the neighborhood than at the city scale, while a very limited number of empirical studies have estimated the relationships at both scales in the same framework. Moreover, much less research has been conducted on the moderating effects of individual socioeconomic attributes and behaviors on the relationship between the built environment and BMI (Schule & Bolte, 2015). Finally, previous studies have focused more on developed countries than on developing countries like China. To address these gaps, in this paper, we examine the relationship between the built environment at both neighborhood and city scales and BMI, and whether the relationship is moderated by individual socioeconomic attributes and behaviors in China, based on a sample of 4114 individuals from the 2012 "China Labor-force Dynamics Survey" project.

The remainder of this paper is arranged as follows. Section 2 briefly reviews the relevant literature on the relationship between the built environment and BMI, and proposes a theoretical framework for this study. Section 3 introduces the variables and datasets used in the empirical analysis, followed by a discussion of the empirical strategy in section 4. Section 5 presents the main empirical results. We discuss the results in section 6. The final section offers conclusions and sets out the limitations of this paper.

2. Literature review and theoretical framework

2.1. The association between the built environment and BMI

In recent years, while a growing body of literature has examined the relationship between the built environment and BMI, the empirical results of these studies have been mixed. Some studies have found that the built environment is not associated with BMI (see the review by Durand et al. (2011) and Feng, Glass, Curriero, Stewart, and Schwartz (2010)), but a considerable number have identified that built-environment elements may decrease BMI by encouraging individual physical activity and affecting travel behavior (see, for example, the chapter in *Handbook of Sustainable Travel* by Handy (2014) and the review by King and Jacobson (2017)). Following Ewing and Cervero (2010), Handy, Boarnet, Ewing, and Killingsworth (2002), and Gul, Sultan, and Johar (2016), in this study, we describe built-environment elements in terms of the "5D" variables of population density, land use diversity, green land design, destination accessibility, and distance to transit, and review the relationship between these variables and BMI.

2.1.1. Population density

Denser neighborhoods are associated with a lower BMI, which could be attributed to the fact that residents in dense neighborhoods often use non-motorized modes of transport as their destinations are close by (Lopez, 2007; Rundle et al., 2007). This argument is supported by many empirical studies that have found a positive association between physical activity (such as walking) and population density (Saelens & Handy, 2008; Wang, Chau, Ng, & Leung, 2016) and a negative association between BMI and physical activity (Frank, Andresen, & Schmid, 2004). However, two studies from China suggest that obesity and physical inactivity likely increase in line with population density (Sun, Yan, & Zhang, 2017; Xu et al., 2010), which is thought to be due to the development of extremely high density cities in China (Alfonzo, Guo, Lin, & Day, 2014).

2.1.2. Land use diversity

Neighborhoods with higher mixed land use have been found to be associated with a lower BMI. One explanation for this may be that more non-motorized travel modes are used in such areas due to the high destination accessibility and proximity along with the highly mixed land use (Frank et al., 2004; Mobley et al., 2006). However, other studies have drawn the contrary conclusion that neighborhoods with higher mixed land use are positively associated with BMI, as the prevalence of commercial facilities in such areas creates more opportunities to shop and eat out (Rutt & Coleman, 2005).

2.1.3. Green land design

Neighborhood greenness was found to have a negative correlation with BMI, as greenness is believed to encourage residents to engage in physical activities such as walking in the neighborhood (Pearson, Bentham, Day, & Kingham, 2014; Pereira et al., 2013), perhaps due to an increase in perceived neighborhood walkability (Wang et al., 2016).

2.1.4. Destination accessibility

Regarding destination accessibility, both higher fitness facilities accessibility (Mobley et al., 2006) and higher park accessibility (Rundle et al., 2013; West, Shores, & Mudd, 2012) were found to be associated with lower BMI. Unsurprisingly, however, fast food restaurant accessibility was found to increase BMI (Li et al., 2009; Xu, Wen, & Wang, 2015).

2.1.5. Distance to transit

Shorter distance to transit facilities (or higher transit accessibility) may reduce BMI by encouraging active travel (MacDonald, Stokes, Cohen, Kofner, & Ridgeway, 2010; Rundle et al., 2007; Sun et al., 2017). Non-motorized modes of travel have a negative correlation with BMI (King & Jacobson, 2017), while driving is positively associated with BMI (Yang & French, 2013).

2.2. Research gaps

Based on our review of the literature, we identified a number of research gaps that motivated our research, which are detailed below:

First, most previous studies have focused solely on the built environment at the neighborhood scale, while few studies have focused on the city scale. Using complex indices to explore the association between urban sprawl/compactness and BMI, a positive association has been found between BMI and urban sprawl (Lopez, 2004) and a negative association between BMI and compactness (Ewing, Schmid, Killingsworth, Zlot, & Raudenbush, 2003, Ewing, Meakins, Hamidi, & Nelson, 2014). To the best of our knowledge, however, only a very limited number of studies have considered the neighborhood- and city-scale built-environment elements within one model about the relationship between built environment and BMI (Ross et al., 2007; Sun et al., 2017; Xu et al., 2015). Given that individual travel purposes are diversified and destinations might be far beyond the neighborhood areas, it is reasonable to hypothesize that BMI is affected by the built environment at different scales, and can be reduced through planning efforts at the city scale (Yang & French, 2013). Therefore, it is necessary to consider the built environment at both neighborhood and city scales, using the same framework to explore the relationship between the built environment and BMI.

Second, it has been argued that the relationship between the built environment and BMI is influenced by the moderating effect of other factors, such as gender and age (Heres & Niemeier, 2017). Thus, previous studies may have had a bias estimation due to ignoring these moderating effects. To the best of our knowledge, much fewer empirical studies have been conducted on the moderating effects of individual socioeconomic attributes and behaviors on the relationship between the built environment and BMI, except for the limited number of studies in which gender was found to moderate that relationship (see the review by Schule and Bolte (2015)). However, these studies only focused on some aspects of the built environment such as green land design (e.g., parks and green spaces) and destination accessibility (e.g., sports facilities, fast food outlets, etc.) (Prince et al., 2012; Wang, Kim, Gonzalez, MacLeod, & Winkleby, 2007).

Third, previous research has focused on developed countries, while little is known about developing countries, except for two studies in