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Neighborhood socioeconomics, food environment and land use determinants of public health: Isolating the relative importance for essential policy insights

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ABSTRACT

Recent literature has advocated the connection between land use policies with public health promotion. In this regard, examining the land use determinants of public health and isolating the relative importance with other influential factors should provide essential policy insights. However, very limited efforts have been made in this aspect, particularly for the developing countries. Using a case of Wuhan (China), this paper attempts to capture the land use determinants of obesity prevalence among middle-aged adults and to compare the relative importance with neighborhood socioeconomics and food environment. A conceptual framework is first proposed to guide the analysis within a land use policy context. Data are then collected during the China's National Physical Fitness Survey in 2010 and multivariate linear regression is applied to analyze the district level determinants. Results show that neighborhood socioeconomics, food environment and land use all have significant effects on obesity prevalence among the middle-aged adults. The men obesity is associated with the occupation, education and housing, while women obesity is correlated with income and housing. Women obesity associates with healthy food environment, while men obesity correlates with unhealthy food environment. Open public space is negative to women obesity, and institutional land is negative to men obesity. Greater walkability and street connectivity associate with lower obesity risk for both genders. The variance decomposition demonstrates that food environment is the most important determinant of men obesity, while land use is the most essential determinant of women obesity. For the obesity prevalence among total population, neighborhood socioeconomics are key determinants. Based on our analysis, we finally provide some insights for land use policies that aim at addressing the obesity issue in developing countries.

1. Introduction

During the past three decades, obesity has been increasing dramatically in developed countries, such as the Austria, Canada, France, New Zealand, UK, and USA (World Health Organization, 2011). Over 50% of European adults and 60% American adults are currently classified as overweight or obese (Ogden et al., 2013). A steady increase in obesity prevalence has also been observed in developing countries since the mid-1980s (Abubakari et al., 2008; Cai et al., 2013; World Health Organization, 2011). It is reported that the obesity rate has tripled among men in China and doubled among women (Tian et al., 2009). The increasing obesity prevalence accounts for substantial chronic diseases, costs and disability, and it therefore recognized as a great threat to public health and well-being worldwide (Ahima and Lazar, 2013; Cornelisse-Vermaat et al., 2006; Protani et al., 2016). Being the biological response to long-lasting positive energy balance, obesity is governed by biology and behaviors at the individual level (Reifschneider et al., 2011; Xu and Wang, 2015). However, these

Abbreviations: OI, obesity incidence; PLIH, percentage of low-income household; PBCW, percentage of blue-collar workers; PPLU, percentage of people in long-term unemployment; IR, illiteracy rate; PENFE, percentage of people receiving no fundamental education; PPDES, percentage of people with degree below elementary school; PHKT, percentage of households without kitchens or toilets; PHBF, percentage of households without bathing facilities; PHTW, percentage of households without tapping water; PHFH, percentage of households without fixed housing; PNP, percentage of non-registered population; PMN, percentage of minor nationalities; DS, density of supermarket; DFFM, density of fresh food market; DFFR, density of fast food restaurant; DCS, density of convenience store; DFSR, density of full service restaurants; PPGS, percentage of public green space; PPOS, percentage of public open space; PIL, percentage of institutional land

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factors cannot explain the shift towards larger body mass index (BMI) at population scale in the past decades (Feng et al., 2010; Huang and Glass, 2008).

Past literature has demonstrated that the population patterns of increasing obesity are associated with socioeconomic and food environmental factors (Ball et al., 2012; Borrell et al., 2010; Mackenbach et al., 2014; McLaren, 2007; Richardson et al., 2015). For example, socioeconomically disadvantaged populations are reported to be disproportionately affected by overweight and obesity (Ministry of Health, 2004; Salonen et al., 2009). Relationships between neighborhood socioeconomics and BMI have been well documented in most developed countries. At the same time, the obesogenic environment theory attributes the obesity prevalence to unhealthy food environment exposure (Mackenbach et al., 2014; Xu and Wang, 2015). Studies have consistently shown the associations between BMI and a variety of measures of food environment (Caspi et al., 2012; Giskes et al., 2011). Despite growing acknowledgment of the neighborhood socioeconomics and food environment contributions, previous cases focus on the developed countries and the overall progress in theory and experience is slow in developing countries (Feng et al., 2010). More specifically, very limited efforts have been spared to investigate the neighborhood socioeconomic and food environment determinants of obesity prevalence in developing countries.

Recent research discovers that health outcomes are closely associated with land use (Brown et al., 2009; Dadvand et al., 2012; Factor et al., 2013; Su et al., 2016a). Scholars have reported a diversity of land use determinants of public health. For example, higher percentage of green land and percentage of green blue land within neighborhood are generally indicative of better physical and mental outcomes (Barton and Pretty, 2010; Bowler et al., 2010; Dadvand et al., 2012; Li et al., 2008; Richardson and Mitchell, 2010; Sugiyama et al., 2016; Zhang et al., 2011). Institutional land and public facilities are also positive indicators of public health (Brown et al., 2009; Su et al., 2016a). On the contrary, industrial land associates with negatively health outcomes in most cases (Cambra et al., 2011; Hendryx et al., 2012; Lopez-Cima et al., 2011; Su et al., 2016a). Additionally, land use mixed pattern and street connectivity are also widely used to indicate better health outcomes (Christian et al., 2011; Factor et al., 2013; Su et al., 2017a; Xu et al., 2015). Land use is supposed to influence obesity prevalence, since people in the neighborhoods with higher percentage of green space and institutional land have greater accessibility to health facilities and higher levels of walking for fitness (Xu and Wang, 2015; Xu et al., 2017). Some pioneered cases report that land use patterns (e.g., land use mix, walkability and street connectivity) also have significant influence on neighborhood obesity (Christian et al., 2011; Factor et al., 2013; Su et al., 2016a; Xu et al., 2015). In particular, better walkability and street connectivity as well as high land use mix are expected to reduce obesity risk. Due to the challenges of computational complexity and data requirements, however, few studies have examined the land use determinants of obesity prevalence, especially in developing countries. Most important, the relative importance of land use, neighborhood socioeconomics, and food environment remains to be poorly understood.

Given the abovementioned shortcomings, this study conducts a systematic analysis of the neighborhood socioeconomic, food environment and land use determinants of obesity prevalence among the middle-aged adults in Wuhan, China. Therefore, the objective of this paper is to capture the land use determinants of obesity prevalence among middle-aged adults and to compare the relative importance with neighborhood socioeconomics and food environment. The findings may ultimately help formulate land use policies that aim to improve public health.

2. Conceptual framework

Previous studies have demonstrated a diversity of frameworks that describe the health determinants under a policy context. Factor et al. (2013) pointed that land use compositions should be essential determinants of health. Langerudi et al. (2015) hypothesized the small scale area association between health and transportation. Vaz et al. (2015) demonstrated the relation of self-reported health to land use. Badland et al. (2015) proposed a framework to select transport indicators to monitor health outcomes within a policy-relevant context. Cartier et al. (2015) demonstrated a tool for the impacts of policy environmental interventions on health. Wan and Su (2016a) presented a theoretical framework to show the links between public health and housing deprivation. Su et al. (2016a) proposed a theoretical framework to show the linkage between public health and land use. Pi et al. (2016) argued that health determinants could be categorized into two aspects, namely the natural and the social one. Su et al. (2017a) assumed the complex interactions among community deprivation, walkability and health. Maiden et al. (2017) proposed a scoring system to evaluate healthy community design in land use plans. These frameworks, while useful for guidance, seldomly exhibit the neighborhood socioeconomics, food environment and land use determinants of public health.

A new conceptual framework (Fig. 1) is proposed to guide the overall analysis. Under the land use policy context, planners can achieve the goal of public health promotion through three approaches. The first one is to regulate the food location and retailing. For example, planners can introduce more healthy food stores (e.g., grocery stores, supermarkets, and organic stores) and restrict the development of unhealthy food stores (e.g., fast food outlets and alcohol retailers) (Robinson et al., 2013; Su et al., 2017b). The second one is to delineate special land use types such as green land, blue land, and institution land to increase the opportunities for active commute and leisure activities (Su et al., 2016a). The third one is to improve the transport convenience (e.g., street connectivity, pedestrian conditions, and walkability) so that residents can enjoy more access to the destinations (Kelly et al., 2014; Saunders et al., 2013; Su et al., 2017a). Land use policy makers are also responsible for eliminating social injustice (Su et al., 2017a). Prior studies have reported that people living in neighborhoods with lower socioeconomic status were more likely to present worse health outcomes (Su et al., 2017a; Weng et al., 2016; Pi et al., 2016). It is argued that neighborhoods with divergent socioeconomic status differ greatly in environmental quality, transport convenience, facilities accessibility, and resources availability (Wan and Su, 2016, 2017; Su et al., 2016b). These discrepancies, as mediating factors, account for the health disparities associated with neighborhood socioeconomic status. It can be summarized that neighborhood socioeconomics, food environment, and land use are three key determinants of public health under the policy context. Nevertheless, these three categories of health determinants are usually interacted and correlated. Isolating their relative importance should help policy makers design and formulate land use planning for public health promotion.

3. Materials and methodology

3.1. Study area and data

Wuhan, a fast growing metropolitan area in central China (Fig. 2), provides a typical case for the topic under examination. Within the Wuhan city, distributions of land use patterns present great socio-geographical disparities, and neighborhoods have no universal access to resources and activities provisioned by the city. Besides, obesity and overweight have been increasing dramatically in Wuhan. However, the public health promotion is not always treated seriously in land use planning. It therefore requires the knowledge of the land use determinants of obesity.

District-level (N = 189) BMI data and obesity incidence for adults aged 35–49 are obtained from the China's National Physical Fitness Survey (NPFS) in 2010. BMI (mass/height^2; unit: kg/m^2) is calculated