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Elucidating the changing socio-spatial dynamics of neighborhood effects on adult obesity risk in Taiwan from 2001 to 2005

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ABSTRACT

Obesity poses a significant health threat in industrialized countries, with its incidence increasing steadily in Taiwan. This study addresses how neighborhood contexts influence individuals, using a multilevel spatial analysis of obesity risk from 2001 to 2005. A priority concern was whether contextual influences on health are limited to the immediate neighborhood or extend to a wider geographical area. The results led to the following conclusions. First, neighborhood factors related to obesity risk are likely to operate over a broad geographical area and are not limited to the focal neighborhood of residence. Second, a geographically based epidemiological change in the likelihood of obesity risk was observed from 2001 to 2005 in Taiwan. Third, the spatial lag model revealed significant spatial spillover of obesity risk in the study area in 2005. Policy interventions are recommended for the neighborhoods associated with the strong spillover effect. The results demonstrate that, in addition to enhancing the accuracy of prediction regarding the effects of neighborhood factors on obesity, incorporating spatial dynamics at the neighborhood level can encourage the development of contextually sensitive policy interventions.

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1. Introduction

Obesity poses a major health risk in industrialized countries. Global analyses indicate that as of 2003 there were more than one billion overweight adults in the world, at least 300 million of whom were obese (World Health Organization, 2003). The rise in obesity is not limited to industrialized countries; in fact, it is often most prevalent in developing countries (Wang and Beydoun, 2007). Approximately 58% of all diabetes cases, 21% of all ischemic heart disease cases, and 8–42% of certain cancers are attributable to being overweight (World Health Organization, 2000). Polygenic, metabolic, psychological, and environmental influences are among the many factors identified as contributing to obesity (Pearce and Witten, 2010). However, overweight status and obesity are not evenly distributed among social and ethnic groups or across geographical areas (McLaren, 2007; Wang and Beydoun, 2007). Research has established a negative correlation of individuals' socioeconomic status (SES) with overweight status and obesity in adults (McLaren, 2007; Monteiro et al., 2004). Multilevel models have also yielded significant correlations between obesity and area-level variables such as differences in income level and SES after individual-level demographic variables such as sex, income, and education are controlled for (Austin et al., 2002; Diez-Roux, 2001; Pickett and Pearl, 2001; Robinson et al., 2003; Cubbin et al., 2006; Chen and Wen, 2010).

Some environments are increasingly recognized as simply more "obesogenic" (obesity promoting) than others (Swinburn et al., 1999). An obesogenic environment refers to "the sum of influences that the surroundings, opportunities, or living conditions that promote obesity in individuals or populations" (Swinburn et al., 1999, p. 564). It is characterized by increased food intake, reduced physical activity, and impoverishment (Swinburn and Egger, 2002). Obesogenic environments drive weight gain and diabetes, especially among members of low socioeconomic groups who lack the ability to alter their environment (Swinburn et al., 1999; Swinburn and Egger, 2002). Several studies have examined the socioeconomic differences in access to environmental entities that could counter obesity. For instance, Horowitz et al. (2004) found that people who live in low-SES areas have less access than people living in wealthier neighborhoods to healthy foods such as low-fat milk, high-fiber bread, and fresh fruits and vegetables. Studying a convenience sample from the US, Moore and Diez-Roux (2006) found that low-income neighborhoods had half as many supermarkets that appeared to provide a wide variety of fruits and vegetables as did the wealthiest neighborhoods. Residents of low-SES neighborhoods may rely on convenience stores or small local vendors where healthy foods are more difficult to find, more expensive, or of lower quality than

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in large retail supermarkets (Cummins and Macintyre, 2002; Cummins et al., 2005; Moore and Diez-Roux, 2006; Horowitz et al., 2004). Outside the US, the evidence concerning access to healthy food is mixed (Cummins and Macintyre, 2006). Pearce et al. (2009) found that people in New Zealand with access to multinational fast-food outlets were the most likely to have the recommended intake of vegetables, but they also tended to be overweight.

The impact of neighborhood characteristics can be both within and between neighborhoods. Previous studies involving the effect of neighborhood characteristics on obesity have modeled neighborhoods as if they were independent of one another, and thus they failed to consider correlations among neighborhoods that were near to one another (Black and Macinko, 2008; for a review). In these studies, neighborhoods were usually defined by census tracts or administrative units. Such definitions, which typically focus on the internal characteristics of neighborhoods, ignore any effects on individual health resulting from interactions between nearby neighborhoods within a broad socioeconomic context. Neighborhoods were simply assumed to have no such interactions. Thus, the potential of placing neighborhoods in a larger system (environment) has generally been overlooked.

The present study extends the frameworks of Morenoff et al. (2001), Morenoff (2003), Caughy et al. (2007), and Chen and Wen (2010) on the spatial patterns of neighborhood effects. Its design was based on the assumption that individuals often work, shop, and attend school far from home. Social processes that reflect a person's lifestyle can therefore extend beyond neighborhood boundaries, thereby creating a wider geographical context for health risks. Neighborhoods should not be treated independently, because factors that affect the risk of obesity in one neighborhood are also likely to affect that risk in nearby neighborhoods. In sum, neighborhoods are interacted with respect to one another can have significant methodological implications for studying the effects of neighborhood characteristics on individual health such as obesity risks.

The purpose of the present study was to employ multilevel hierarchical regression models to examine the effect of individual SES, within-neighborhood, and between-neighborhood variables on obesity risk (elevated BMI) at the level of the individual. Three research questions were addressed. First, do neighborhoods at high risk of elevated BMI exist within heterogeneous socioeconomic clusters characterized by affluence and poverty and did these spatial clusters change their locations from 2001 to 2005 in Taiwan? Second, if the results suggest that individual risk of elevated BMI is related to the characteristics of adjacent neighborhoods, is the risk likely to shift from a given neighborhood to adjacent neighborhoods over time? Spatial lag regression models and the spatial multiplier estimation have been used to examine spatial diffusion (Anselin, 2009). Third, have socioeconomic differences in individual risk of elevated BMI changed over time among Taiwanese adults?

2. Background

2.1. Neighborhood differences, neighborhood interactions, and obesity risk

Since the early 1990s, exactly how neighborhood differences as distinct from individual differences affect health has been extensively studied (Diez-Roux, 2001; Pickett and Pearl, 2001; Kawachi and Berkman, 2003). Considerable variation in mortality and other health outcomes such as hypotension and obesity have been demonstrated across geographical localities. Black and Macinko (2008) demonstrated that socioeconomic composition is the structural characteristic of neighborhoods most strongly related to obesity risk. Significant correlations with the prevalence of obesity have been found for neighborhood SES indicators such as per capita income and education (Janssen et al., 2006; Nelson et al., 2006), poverty (Boardman et al., 2005), community socioeconomic disadvantage (Robert and Reither, 2004), material deprivation (van Lenthe and Mackenbach, 2002), and the unemployment rate (Janssen et al., 2006). Cummins et al. (2005) demonstrated that neighborhood poverty in Scotland and England was associated with an increased likelihood of a McDonald's fast-food restaurant in the neighborhood. Chaix and Chauvin (2003) found the risk of being overweight or obese to be related to neighborhood GDP, but only for blue-collar workers. In China, however, adult obesity is most common among high-income people and low-income women living in economically developed areas (Popkin et al., 1995). In addition, the relation between income inequality in a neighborhood and weight status has seldom been evaluated, with the few studies yielding inconsistent results (Black and Macinko, 2008).

Racial/ethnic segregation in the neighborhood is another possible risk factor for obesity. Segregation, which is a product of racial discrimination, has been shown to adversely affect both physical and mental health (Williams and Collins, 2001). Individuals living in neighborhoods where more than 25% of the population is African American have been found to have a 13% greater probability of obesity than individuals living in other neighborhoods (Boardman et al., 2005). On the other hand, Mobley et al. (2006) and Robert and Reither (2004) found that neighborhood racial composition and obesity risk were not significantly related. Chang (2006) demonstrated that racial isolation induced obesity among African Americans, but not Caucasians. Lin et al. (2003) found that people residing in mountainous regions of Taiwan, most of whom are aboriginal, were prone to obesity. The increased obesity in these people is attributable to their poor SES and social isolation.

Whether place of residence influences health, and thus increases individual differences in health, has received considerable research attention (Black and Macinko, 2008). However, all the studies of the effects of neighborhood characteristics on health that modeled neighborhoods as independent entities failed to analyze relevant conditions in nearby neighborhoods (Diez-Roux, 2001; Pickett and Pearl, 2001; Kawachi and Berkman, 2003). Additionally, the possibly important fact that neighborhoods belong to a larger social environment has been neglected in studies of the effects of neighborhood characteristics on health. More recent efforts to study these neighborhood effects have expanded the geographical context to include nearby neighborhoods outside the administratively defined focal neighborhood (Sampson et al., 2002). These authors claimed that social behavior is influenced not only by what occurs in one's own neighborhood, but also by what occurs in surrounding areas (Smith et al., 2000; Morenoff et al., 2001; Sampson et al., 2002; Morenoff, 2003; Caughy et al., 2007). Smith et al. (2000) demonstrated that socially fragmented neighborhoods with low expectations of social control created contextual disadvantages not only for parents and children living in a given neighborhood, but also for those living in adjoining neighborhoods. Morenoff (2003) found that neighborhoods share participation in local associations will generate activities that benefit the health of women in both focal and adjacent neighborhoods (Morenoff, 2003, p. 1011). The above studies demonstrate that research on the effects of neighborhood characteristics on public health should focus not only on the focal neighborhood but also on the larger environment in which that neighborhood is embedded.

The use of spatial analysis techniques to uncover the connection between social and geographical factors is essential for

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