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Lifting the lid on geographic complexity in the relationship between body mass index and education in China

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ABSTRACT

In China, rising obesity has coincided with increasing affluence. Few studies have properly accounted for geographic variation, however, which may influence prior results. Using large data with biomarkers in China, we show body mass index (BMI) to be positively correlated with higher person-level education if estimated using ordinary least squares. In stark contrast, fitting the same data within a multilevel model gives the complete opposite result. We go on to show that the relationship between BMI and person-level education in China is dependent upon geography, underlining why multilevel modelling is crucial for revealing these types of people-place contingencies.

1. Introduction

Rising prevalence of overweight and obesity coinciding with rapid economic development and increasing affluence in China has been well documented (Chen, 2008; Popkin et al., 1995; Wu, 2006; Xi et al., 2012; Zhao et al., 2008). Some studies in China have subsequently reported higher body mass index (BMI) among more affluent groups (Reynolds et al., 2007; Wang et al., 2006). Meanwhile, other studies in China have reported more equivocal findings, including both higher and lower BMI in more affluent groups (Du et al., 2004; Jones-Smith et al., 2011; Tafreschi, 2015; Xiao et al., 2013). The observation of higher BMI with more favourable socioeconomic circumstances contradicts the widely recognised negative correlation between BMI and socioeconomic circumstances in high-income countries (Caballero, 2007).

In China, like other developing countries, higher BMI manifesting among more affluent groups may be – to a potentially large extent - due to the availability of energy-dense 'western-style' fast food, refined and processed carbohydrates, processed meats, and drinks loaded with sugar, which have historically only been affordable to more affluent groups (McLaren, 2007; Monteiro et al., 2004; Sobal and Stunkard, 1989; Subramanian et al., 2011). It is known that food corporations have targeted more affluent groups and especially younger generations to advertise western-style food (Curtis and McCluskey, 2007; Hawkes, 2007). Major fast food retailers have selected to co-locate or cluster within particular areas where consumer profiles – more affluent groups – are known to reside (Gao, 2013; Shen and Xiao, 2014; Zhang et al., 2012). Concerns over food safety (Lam et al., 2013; Pei et al., 2011) have contributed to many people willing to pay more (if they can afford) for food they perceive as safe (Liu et al., 2013). Food and drink multinationals have successfully exploited these concerns to align their brands with health, strength and fashion (Gao, 2013; Pan et al., 2012). In short, the 'western-style' diet has been targeted geographically, monetarily and psychologically at China's affluent classes who mainly

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live in cities (Fu and Land, 2015).

That said, shifts from more traditional dietary patterns of vegetables, whole grains and low consumption of animal products to more 'western-style' diets, combined with the expansion of access to motorised transport and labour-saving technologies in more affluent areas (Ng et al., 2014), are unlikely to have been exclusively the preserve of the most affluent. China's cities are socioeconomically heterogeneous and 'western-style' food and drink is now also increasingly affordable to some lower-income households (Du et al., 2002; Zhai et al., 2009). Consequently, some have suggested that the mixed findings with respect to the socioeconomic gradient in BMI in China reflects a reversal over time, from positive to negative (Pampel et al., 2012; Philipson and Posner, 2003).

However, economic development in China has been geographically uneven and is suggested to have exacerbated health inequity (Tang et al., 2008). It is unlikely that the reversal hypothesis, if true, is occurring in all parts of China simultaneously. Consequently, there are potentially important between- and within- area differences in the socioeconomic gradient of BMI that are yet to be fully explored given that most studies on this topic in China are either limited to specific areas, or use nationally representative surveys but without explicit attention to the interface between people and place. Accordingly, in this paper we report on a study that illustrates the importance of using multilevel modelling to explore potential spatial contingencies in the association between BMI and socioeconomic circumstances in China and in other contexts experiencing epidemiological transition.

2. Methods

2.1. Data source

Data for the study w obtained for 98,058 adults in 2010 from the China Noncommunicable Disease Surveillance survey. In-depth details of data collection and representativeness of the survey are already published (Li et al., 2013; Zhao and Ning, 2012; Zhou et al., 2015). Briefly, this is a nationally representative health survey of 109,023 adults aged 18 years and older. Data collection was conducted by the National Center for Chronic and Noncommunicable Disease Control and Prevention between August and December 2010. The China Center for Disease Control and Prevention's (China CDC) ethics committee approved the study.

The China Noncommunicable Disease Surveillance survey was based upon the National Disease Surveillance Points system (DSP). The DSP consists of 161 counties randomly selected from all 7 geographical regions (Northeast, North, East, South, Southwest, and Northwest and Central areas). The sample has been shown to be nationally representative, and includes counties from all 31 provinces, municipalities and autonomous regions in mainland China, accounting for approximately 7% of the population (Zhou et al., 2015; Zhou, 2010).

Participants were selected via a complex, multistage probability sampling design within each DSP, with 4 sub-districts selected with probability proportional to population size. Within each sub-district, 3 neighbourhood communities or administrative villages were then selected proportional to population size. Within each community or village, 50 households were randomly selected from a comprehensive listing. A Kish selection table (Kish, 1949) was used to select 1 person from each household at random. All participants were civilian, non-institutionalized adults. Only participants that had lived for 6 months or longer at their residence were eligible. Written informed consent was obtained from all participants prior to data collection. If an individual was ineligible, refused or was unavailable, a replacement household was selected from the initial list minus those households previously selected. These replacements ensured a sufficient sample size and representativeness of the data across the country.

Objective measures of height and weight were collected by trained staff within examination centres at health stations or community clinics nearby participants' homes. The survey was also administered by trained interviewers and included questions on socio-demographics, medical history, lifestyle-related factors and health service use. Further information on the survey is available elsewhere (Xu et al., 2013). There were a total of 98,658 participants in the survey, with an overall response of 90.5% and a replacement of 9.25%. A total of 600 participants with missing values of interest were excluded, leaving an analytical sample size of 98,058.

2.2. Outcome variable

BMI(weight in kilograms divided by the square of height in metres) is the main outcome for the study, based upon objective measures of height and weight. BMI was analysed as a continuous variable given debates within the literature as to the appropriateness of WHO guidelines for classifying overweight and obesity in the Chinese population (Zhou and the Cooperative Meta-analysis Group of Working Group on Obesity in China, 2002).

2.3. Socioeconomic circumstances

Socioeconomic circumstances was measured using education-based variables, since these are less prone to reverse causation and reporting bias than other indicators, such as household income (Galobardes et al., 2006a, 2006b). Two indicators were used, one measured at the person-level and a second at the area-level. The taking of this simultaneous person- and place-based approach to operationalise socioeconomic circumstances was in order to contrast the (dis)advantage that a person may have relative to the average level of (dis) advantage of other people who they share the same spatial context with. Some degree of correlation between the socioeconomic circumstances at the person-level and area-level is to be expected depending upon the geographical scale used for measurement. It is likely that a higher degree of correlation would manifest with person-level socioeconomic circumstances when the area-level variable is measured at very local scales (e.g., among families in a street or neighbourhood). Theoretically, the socioeconomic homogeneity expected for small geographical scales would be inappropriate as, in effect, it would likely be almost identical to the person-level variable and inform little about the prevailing context in which a person resides. Accordingly, the county administrative level was utilised in order to provide grounds for identifying 'off-diagonal' cases with which to examine the patterning of BMI among more affluent people living in less affluent areas and vice-versa.

The person-level indicator of socioeconomic circumstances was measured by asking participants what their highest educational qualification was. Answers were categorised as "none/less than primary school", "primary school", "secondary school", or "university". The area-level indicator of socioeconomic circumstances was based upon Census data measured at the county level. The Census provides information on the average number of years of educational attainment among adult residents within each county. This variable ranged from 5 to 13 years, with a mean of 9 years of educational attainment. This approach was used to offer potentially contrasting insights based upon a person's level of education relative to the average education level of the people with whom they lived, in line with ongoing work in the area of relative inequality (Wilkinson and Pickett, 2009).

2.4. Statistical analysis

The association between person-level education and BMI was initially tested using an Ordinary Least Squares (OLS) linear regression (Model 1). This model was used to provide a basic insight into the association between BMI and socioeconomic circumstances without taking into account sample design or geographical location.