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Abstract

While urbanization is associated with a wide range of human welfare outcomes, its impacts on population health are much less obvious. This article aims to investigate how rapid urbanization in contemporary China affects health, and how it shapes health disparities between groups of different socioeconomic status (SES). Using data from eight waves of the China Health and Nutrition Survey (CHNS) spanning a period of 20 years from 1991 to 2011, we examine the confounding effects of urbanization on health and the income-health relationship and explore the underlying mechanism. Results from multilevel analysis show that living in more urbanized areas increases the risk of acquiring chronic diseases, and the health penalty of urbanization is more severe among those with a higher income. Lifestyle is the pathway through which urbanization affects health, and a high-fat diet and decreased physical activity weaken the income-health relationship and accelerate health decline in more urbanized areas. These results suggest an urgent need to design and implement health promotion programs to encourage healthy lifestyles in China under rapid urbanization.

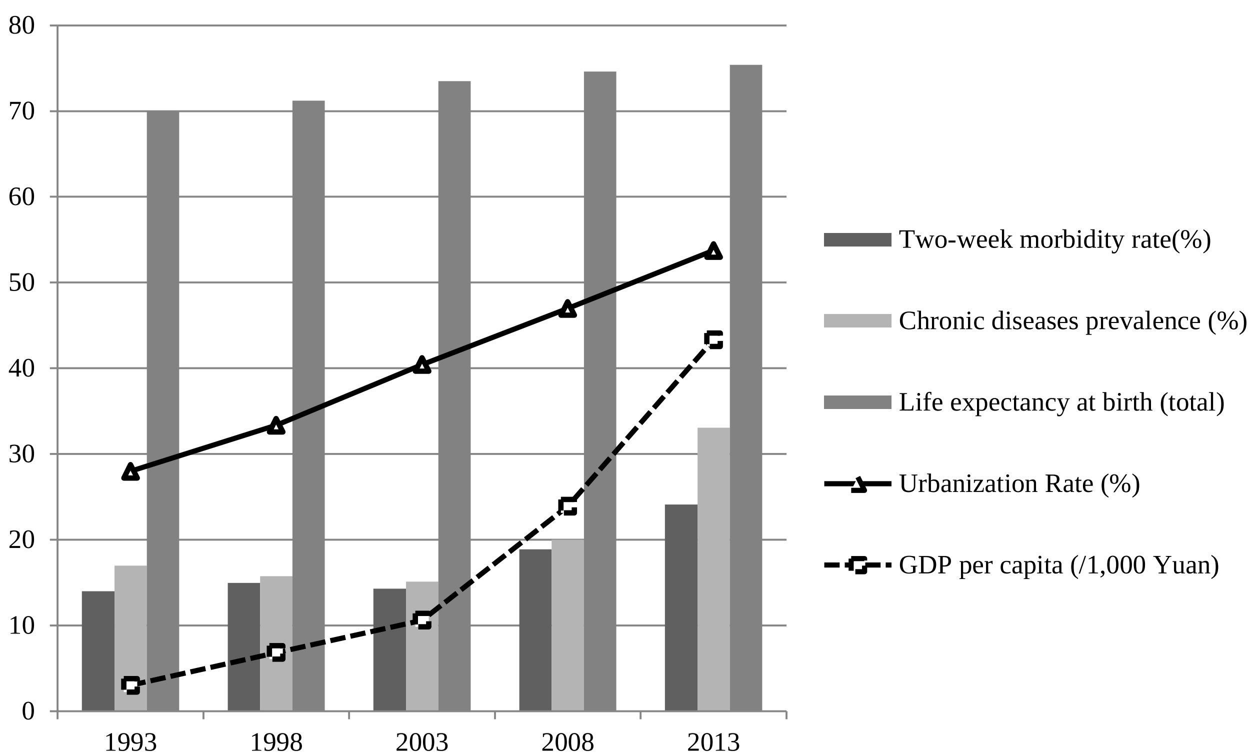
Highlights

- Living in more urbanized areas raises the risk of developing chronic diseases.
- The health penalty of urbanization is more severe among higher-income earners.
- Rapid urbanization accelerates the spatial concentration of people adopting unhealthy lifestyles.
- An unhealthy diet and decreased physical activity contribute to the negative effects of urbanization on health.

INTRODUCTION

China is experiencing urbanization on a scale unprecedented in human history. The percentage of the country's population living in cities increased from 18 percent in 1978 to 55 percent in 2015 (National Bureau of Statistics, 2015). It is anticipated that its urban population will grow by another 350 million by 2025 and that 1 billion people will live in cities by 2030 (Development Research Center of the State Council, 2014). Aside from its other profound consequences, urbanization plays an increasingly important role in shaping population health and socioeconomic status (SES)-related health disparity in China. The health consequences are mixed. On the one hand, urban residents may benefit from improved sanitation, infrastructure and access to health services; on the other, they may come across other problems including income inequality, unhealthy lifestyles, and environmental pollution in cities. In China, urbanization has been accompanied by improved living standards and longer life expectancy, yet the prevalence of chronic diseases and growing number of unhealthy people may suggest a health penalty (see Figure 1).

Figure. 1. Rapid urbanization, GDP growth, life expectancy and morbidity rate in China, 1993-2013. Sources: China Statistical Yearbooks; China Health and Family Planning Statistical Yearbooks; World Bank



The impact of urbanization on people's health may vary by their SES. However, whether urbanization widens or narrows the health disparity between groups of different SES is still debatable. Urban life may increase the health inequality by putting the disadvantaged group in "double jeopardy". Since the prices of health products and services are somewhat determined by the average income level, a higher income inequality in the city would render these resources more unaffordable for the poor (Bassuk, Berkman and Amick, 2002; Du et al., 2004; Fan and Rizzo, 2012; Robert, 1999). Yet, urbanization may also flatten the SES gradient in health, because improved sanitation and built environment as well as better access to health information in cities would also benefit the poor. Higher-income earners, especially those in developing countries, may be at higher risks of stress, decreased physical activities, over-nutrition and unsafe sex (Kim and Popkin, 2004; Maruapul, 2011; Zhu, 2011).

The existing literature on this issue focuses on either large cities in developed countries or ghettos in developing countries. It is unknown whether, and if so to what extent, the observed effects are specific to these urban settings. Empirical research on China rarely examines the impact of urbanization on health inequality and its underlying mechanisms. It is unclear how the dramatic changes in the social, demographic, and living environments influence the health profile of the Chinese population. Our study attempts to fill these gaps by investigating two questions: 1) How does urbanization affect health and the SES-health relationship in communities with various levels of urbanization in China? 2) Through what channels does urbanization exert these impacts?

This study contributes to the literature in several respects. First, the article adds new knowledge to the study on health and urbanization by providing evidence from a booming economy and communities of various sizes. Second, it enhances our understanding of health inequality in China by revealing how social changes are intertwined with individual attributes to generate health gaps among various SES groups. Third, it sheds light on the mixed results from previous studies by analyzing the mechanisms of urbanization's effect on health. The findings of this study have implications for Chinese government policies aiming to further promote urbanization to fuel its economic growth.

LITERATURE REVIEW AND BACKGROUND

Urbanization, SES, and Health

Urbanization is associated with a wide range of health outcomes, including infant mortality, chronic diseases, obesity, sexually transmitted diseases and mental illness (Allender, 2008; Delisle et al., 2012). Previous studies generally supported the idea that the relationship between urbanization and health is complex, because each dimension of urban life affects health in its own way and the effects vary with the specific social and cultural contexts (McDade and Adair, 2001; Gelea and Vlahov, 2005). For instance, urbanization may lead to lower rates of infant mortality and infectious diseases due to improved infrastructure, sanitation and access to health services and knowledge. But in developing countries where the population density is too high, sanitation remains unsatisfactory and health services leave much to be desired, urbanization is linked to poorer health (Galea and Vlahov, 2005; Vlahov et al., 2004).

People of higher SES generally enjoy better health outcomes (Link and Phelan 1995), and this SES gradient in health may be affected by urbanization. Double jeopardy theory claims that urban life raises the importance of SES in health protection, because living costs are higher and physical and psychological stressors are more concentrated in cities than in rural areas (Robert, 1999). A comparative study of 47 countries found that health disparities between the rich and the poor within the city were even more distinctive than those between urban and rural residents (Van de Poel, O'Donnell and Doorslear, 2007). Another theory predicts a flattened SES gradient in health in cities. Studies revealed that the health benefits that come with a better income may be outweighed by the unhealthy lifestyle and environmental deterioration associated with urbanization in some countries, while the urban poor may experience improved health through access to health facilities such as hospitals and primary health care services, as well as various health information through educated members in their network (Cesare et al., 2013; Van de Poel et al., 2009, 2012; Allender et al., 2008).

Considerable studies have reported the health penalty of urbanization in China (Chen et al., 2014; Gong et al., 2012; Jones-Smith and Popkin 2010; Van de Poel et al., 2012). Longitudinal studies showed that urbanization was related to hypertension, obesity and decreased self-reported health (Van de Poel et al., 2009; 2012). Using nighttime light data and remote sensing image analysis, researchers found that more urbanized regions were associated with a higher prevalence of chronic diseases, and poorer self-reported physical and mental health (Li et al., 2012; Chen et al., 2014). The effects of SES on health may be different for the urban and rural populations. Based on a decomposition analysis, Yang and Kanavos (2012) found that income and educational attainment had more prominent influences on health inequality in cities than in rural areas. For the urban population, 76-79 percent of inequalities were driven by socioeconomic-related factors, compared with only 48 percent for the rural population. Hence, there is evidence suggesting that urbanization strengthens the SES-health relationship.

Lifestyle as a Mechanism

How does urbanization affect health and health differentials between the rich and the poor? A significant body of research has pointed to the importance of lifestyle. Health lifestyle theory claims that lifestyle is a bridge between structure and human agency and affects health outcomes through a two-step process (Cockerham, 2005). In the first step, structural conditions shape people's life chances (lifestyle options). In this case, people living in urban areas would be exposed to more diverse choices of lifestyles—including unhealthy lifestyles—than their rural counterparts. In the second step, people choose their preferred lifestyles from the limited options, according to their SES background (life choice). People of higher SES generally have healthier lifestyles, as they are more likely to commit to regular exercise, adopt healthy diets and receive physical checkups (Elo 2009; Robert and House, 2000; Pampel et al., 2010). However, considerable studies conducted in developing countries also found that higher-income groups are more likely to smoke, drink and adopt high-calorie diets (Danaei et al., 2013; Delisle et al., 2012; Kim et al., 2004; Sodjinou et al., 2008). One possible explanation is that certain unhealthy lifestyles are actually considered privileges in these countries.

China's rapid urbanization is accompanied by widespread unhealthy lifestyles. The Chinese diet has shifted from ones consisting primarily of complex carbohydrates and fiber toward ones loaded with fats, saturate fats and sugars (Drewnowski and Popkin, 1997). Unlike people in the U.S., Chinese people adopt a more unhealthy diet as their incomes increase (Kim et al., 2004).

Meanwhile, there has been a tremendous decline in the intensity of occupational activity in China since the 1990s (Popkin et al., 2007, Ng et al., 2009). Since leisure activities and exercise have not grown as popular as they have in western countries (Bell, Ge and Popkin 2001), the decreased occupational activity indicates various health risks including obesity and hypertension (Van de Poel et al., 2009). The findings led many scholars to the conjecture that lifestyle is the mechanism of the urbanization effect (Gong et al., 2012). Nevertheless, limited empirical studies have directly tested this conjecture.

The Present Study

Previous studies have provided informative evidence on the relationships between urbanization, SES and health. However, several important questions await further exploration. First, few studies have evaluated whether urbanization affects the SES-related health inequality in developing countries and in the context of medium-/small-sized communities, so our picture of the health consequences of urbanization remains sketchy. Second, studies on China have rarely tested whether or not lifestyle is the mechanism through which urbanization influences health and health disparities. The answer is important to understand the health inequality in China and to design effective health promotion programs. Third, the existing literature has mainly employed a dichotomous administrative definition to measure urbanization, which may fail to trace the changes in urban elements. Multiple studies have employed night-light data to measure urbanization (Li et al. 2012, Chen et al. 2014). This method is creative for capturing urban expansion over time, but the reliability of the measurement may be sensitive to several conditions including the location of large infrastructure projects and energy efficiency strategies of cities.

In this study, we explore how urbanization influences the SES gradient in health and examine its mechanisms using a nationally representative, longitudinal dataset spanning 20 years. We adopt a time-varying continuous measure of urbanization that can capture the accumulative process of urbanization and its effects on health.

METHODS

Data

This study uses the China Health and Nutrition Survey (CHNS) data from 1991, 1993, 1997, 2000, 2004, 2006, 2009 and 2011. Adults aged 18-60 years old in each wave are included in the analyses. The CHNS was designed to examine how socioeconomic changes in China affect the health and nutritional status of the population. Using a multistage, random cluster sampling method, the survey collects extensive information on individuals, households and their communities in 12 provinces in China: Liaoning (from 1997 onwards), Shandong, Beijing (from 2011 onwards), Shanghai (from 2011 onwards), Jiangsu, Henan, Heilongjiang (not in 1997), Hubei, Hunan, Chongqing (from 2011 onwards), Guangxi, and Guizhou. It provides unique, large-scale longitudinal data to study health issues in post-reform China. We exclude respondents who reported being physically handicapped or pregnant during the survey year. After leaving out any observations with missing information for any individual- or community-level variables, the sample size for analysis is 57,358 person-year records.

The descriptive statistics for the working sample are presented in Table 1. The average age of respondents is 40.6. Sixty-two percent of them have completed junior high school education. The average prevalence rate of chronic diseases over the 20 survey years is 9.5 percent. On average, respondents obtain 27.5 percent of their energy from fat. According to Chinese Dietary Reference Intakes 2013 (DRIs 2013), adults should not obtain more than 20-30 percent of their calories from fat in order to stay healthy. The high percentage reported in the survey indicates the potential widespread risk of hypertension and obesity.

Table 1. Descriptive statistics of the working sample, CNHS 1991-2011 (N=57,358)

Variable	Mean	Standard Deviation
Urbanization Index	59.28	20.65
Prevalence of Chronic diseases	0.09	0.33
Per Capita Household Income (Inflated to 2011)	7591.77	8036.52
Age	40.58	11.33
Male	0.47	
Married	0.84	
Highest Education Completed		
Junior High School	0.35	
Senior High School	0.27	
Percent of Calories from Fat	27.52	11.74
Physical Activity Level (1=very light, 5=very heavy)	2.89	1.17
Medical Insurance (Yes=1)	0.47	
Drinking (Yes=1)	0.36	
Smoking (Yes=1)	0.30	
Living in the north	0.40	

Measurement

1. Health Status

This study focuses on physical health status, measured by diagnosed chronic diseases. It is obtained from the question: "Has a doctor ever told you that you suffer from the following diseases? High blood pressure/diabetes/myocardial infarction/stroke or transient ischemic attack/bone fracture/asthma." These diseases accounted for 53 to 56 percent of deaths in China during 1990-2012 (China Health Statistics Yearly Book 2015). We treat health status as a count variable ranging from 0 to 6.

Chronic diseases may be a more appropriate measurement for health status in this study than self-reported health as the latter is highly sensitive to individuals' expectations. By altering the living standards and the neighborhood environment, urbanization may greatly change an individual's health expectations (Wen et al., 2006).

This measure, however, may suffer from an underreporting bias. Rural people and the poor are less likely to visit a doctor than urban and rich residents, so the negative effect of urbanization and income may be overestimated. To address this potential problem, we include medical insurance enrollment in the estimation to capture the effect of medical resource accessibility. In addition, we anticipate that the underreporting problem may not be so severe as to violate our estimation for two reasons. First, CHNS collects biomarker information after interviewing its subjects, including measuring their blood pressure. A respondent who has just been told he/she may have high blood pressure is very likely to seek further diagnosis. Second, in 2003 the Chinese government implemented the New Cooperative Medical Scheme in rural areas, with the aim of reaching universal coverage by 2010 (Luo and Tong, 2016). To encourage peasants to take part in this scheme and to achieve the goal set by the central government, it is a common practice for local governments to offer peasants free physical examinations. Thus, systematic differences in the diagnosis of chronic diseases between urban and rural areas may decrease over time.

2. Urbanization

We measure urbanization by the urbanization index constructed by Jones-Smith and Popkin. Using data collected from CHNS community surveys, they designed and validated a multi-component scale to measure urban features on a continuum in China (Jones-Smith and Popkin, 2010). The index measures 12 aspects of urbanization, namely population density, economic activity, traditional markets, modern markets, transportation and health infrastructure, sanitation, communication, social services, diversity and housing. The detailed construction procedure and the dataset of the index are available on the CHNS website.[1] The index outperforms the dichotomous administrative measure in two ways. First, it uses data collected from 309 communities, within which households were selected for the survey. Therefore it is able to capture more accurately the community attributes that affect local residents. Second, it represents gradations on the continuum from rural to urban environments, and so it can capture changes in a community and their effects.

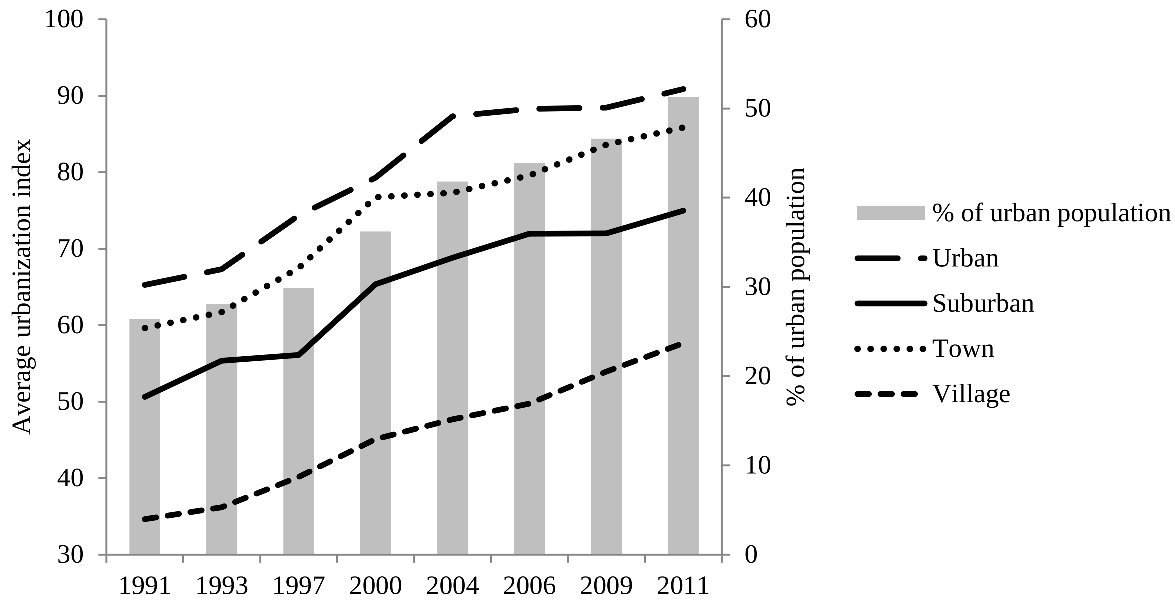
We demonstrate the distribution of the index over eight survey years. The index consistently matches the data released by the National Bureau of Statistics (as shown in Figure 2). We also examine index changes in four types of communities according to administrative definition. Cities reported the highest index scores, followed by towns, suburban areas and villages. Suburban areas and towns experienced the rapidest change. The greatest variance was found among suburban areas (not shown in the figure), which indicates large-scale city expansion in some places. For instance, provincial capital cities and economically developed cities had more resources and higher motivation to merge the rural communities on their fringes. It is clear that communities within the same administrative group may differ significantly in the level of development. The administrative measure fails to capture these differences within administrative boundaries.

3. Individual SES

This study measures individual SES by income. Because half of the respondents come from rural areas and are not engaged in any paid employment, we use household income per capita to reflect their economic status. The income data are inflated to 2011. To capture the potential non-linear effects of income on health, we measure income by a dichotomous variable: respondents in the top quintile of the household income distribution are coded as the high-income group. We repeat the estimation using logarithmic income and a quadratic term of income. The result is not significantly different from that using the dichotomous measurement. We thus choose the dichotomous one for ease of interpretation.

[1] Detailed information and the dataset can be found at http://www.cpc.unc.edu/projects/china/data/datasets.

Figure. 2. Urbanization index of the urban area, suburban area, towns and villages, 1991-2011. Sources: China Statistical Yearbooks; CHNS 1991-2011



4. Lifestyle

Two dimensions of lifestyle are examined in this study: dietary intake and physical activity. We use percentage of calories obtained from fat to measure dietary style. Using the 24-hour dietary recall and weighting methods, the CHNS provides rich information on food consumption. To capture respondents' daily energy consumption, the CNHS asks detailed questions about five types of physical activity: occupational activity, commuting, domestic work, physical exercise and recreational activities. Based on this information, respondents' level of physical activity is graded as very light, light, moderate, heavy, very heavy or other. The "other" category mainly includes people who have physical disabilities. In the analysis we exclude this category, resulting in 186 cases being deleted. This composite variable is available on the website of the CHNS.[2]

5. Control variables

In addition to individuals' demographic characteristics (i.e. age in month, gender and marital status), we control for educational attainment, alcohol consumption, tobacco use, medical insurance enrollment and labor market participation. These factors are believed to be distributed

[2] http://www.cpc.unc.edu/projects/china/data/datasets/data_downloads/longitudinal.

unevenly between rural and urban areas, and are highly associated with chronic diseases. Northern and southern Chinese adopt significantly different lifestyles and encounter different health risks. We control for whether respondents live in the Northern provinces. We also include survey-year fixed effects to remove year-specific heterogeneity.

Statistical analysis

We formulate a two-level hierarchical Poisson regression to estimate the effect of urbanization on health and the income-health relationship,[3] characterized by the following equation:

Level-1 Model (individual-level):

$$\log(Health_{ij}) = \pi_{0j} + \pi_{1j}(Income)_{ij} + \Gamma X_{ij} \quad (1)$$

Level-2 Model (community-level):

$$\pi_{0j} = \beta_{00} + \beta_{01}(Urbanization)_j + r_{0j} \quad (2)$$

$$\pi_{1j} = \beta_{10} + \beta_{11}(Urbanization)_j + r_{1j} \quad (3)$$

The level-1 model estimates the risk of acquiring chronic diseases depending on a set of individual characteristics. $Health_{ij}$ is the total number of chronic diseases that respondent *i* in community *j* was diagnosed as having. $Income_{ij}$ is a dichotomous variable that is equal to 1 if the respondent is in the top quintile of the household income distribution. X_{ij} is a vector of individual-level control variables. Following the multilevel analysis literature, we center all continuous variables on the grand mean (Raudenbush 2002).

The level-2 model assesses the heterogeneity in the odds to developing diseases across communities, and determines how income level interacts with urbanization and then affects health outcome. The impact of income, π_{1j}, is divided into two components: the mean income effect across all communities (β_{10}) and the community-specific income effect. The latter also consists of two components: the effect related to urbanization level (β_{11}), and the random effect associated with each community (r_{1j}). Similarly, the mean level of individual health status π_{0j} is further modeled as community mean health (β_{00}) plus health variation determined by

[3] The mean of the dependent variable is 0.09 with variance of 0.10. The test shows that there is no over-dispersion, and the Passion model is appropriate in this case. We also ran negative binomial models and found no significant difference between the two estimations. The results are available upon request.

urbanization level (β_{01}) and variation (γ_{0j}) not captured by the multilevel model. We are interested in both β_{01} and β_{11}, which indicate how health varies with urbanization level, and how urbanization and income jointly shape individual heath.

To explore the underlying mechanism of urbanization effects on health, we test whether or not unhealthy lifestyles are more prevalent in more urbanized areas, and whether the high-income earners are more likely to adopt these lifestyles. We formulate three-level growth curve models to capture the individual trajectory of lifestyle changes, and to examine how these changes were affected by the urbanization process (Raudenbush 2002). The models are as follows:

Level-1 Model (within-individual):

$$Y_{tij} = \pi_{0ij+}\pi_{1ij}(Age)_{tij} + \pi_{2ij}(Age^2)_{tij} + \pi_{3ij}(Income)_{tij} + \pi_{4ij}(educ)_{tij} + \pi_{5ij}(Married)_{tij} + e_{tij}$$

Level-2 Model (between-individual, within-community):

$$\pi_{oij} = \beta_{00j} + \beta_{01j}(Male)_{ij} + \beta_{02j}(North)_{ij} + r_{0ij}$$

$$\pi_{1ij} = \beta_{10j} + r_{1ij}$$

$$\pi_{2ij} = \beta_{20j}$$

$$\pi_{3ij} = \beta_{30j} + r_{3ij}$$

$$\pi_{4ij} = \beta_{40j}$$

$$\pi_{5ij} = \beta_{50j}$$

Level-3 Model (between communities):

$$\beta_{00j=}\gamma_{000} + \gamma_{001}(urbanization)_j + \mu_{00j}$$

$$\beta_{01j=}\gamma_{010}$$

$$\beta_{02j=}\gamma_{020}$$

$$\beta_{10j=}\gamma_{100} + \mu_{10j}$$

$$\beta_{20j=}\gamma_{200}$$

$$\beta_{30j=}\gamma_{300} + \mu_{30j}$$

$$\beta_{40j=}\gamma_{400}$$

$$\beta_{50j=}\gamma_{500}$$

The level-1 model characterizes the within-individual change over time. In this model of repeated measurement within individuals, Y_{tij}—the calorie consumption or intensity of activity of respondent *i* in community *j* at time *t*—is modeled as a function of time-variant personal attributes, including age (in month), quadratic term of age, educational attainment, income and marital status. The level-2 model assesses inter-individual differences in adopting unhealthy lifestyles. β_{01j} and β_{02j} are coefficients for the intercept model that capture gender and regional differences in the mean prevalence of unhealthy lifestyles. The change rates of age (π_{1ij}) and income (π_{3ij}) are assumed to vary by individual. Thus, they are modeled as the individual mean (β_{10j} or β_{30j}) plus random effects associated with each individual (r_{1ij} or r_{3ij}). We test similar models for other individual predictors but omitted them here to conserve space. Similarly, in the level-3 models, each community's mean prevalence of unhealthy lifestyles, β_{00j}, is modeled as the sum of three parts: grand mean prevalence, prevalence associated with urbanization and other community heterogeneity.

EMPIRICAL RESULTS

Descriptive Statistics

We first calculate the means for the urbanization level, prevalence of chronic diseases and lifestyle for each survey year to examine the changes over time. Table 2 shows that the incidence of chronic diseases dramatically increased over the 20–year period. In 1991 only 2.55 percent of respondents reported experiencing disease symptoms. The number skyrocketed to 18.16 percent in 2011. The result is consistent with figures released by the Chinese Center for Disease Control and Prevention (China CDC, 2012).

There is concern that people in more urbanized areas tend to live longer due to improved public health and living conditions, and as a result they are more likely to suffer from chronic diseases. We calculate the prevalence rate of chronic diseases by age group for communities at various urbanization stages. Within each age group, people living in more urbanized areas reported more chronic diseases than residents in less urbanized communities (shown in Appendix 1). Data China National Health and Family Planning Commission also show that the mortality rate of the major causes of death in urban and rural China converged in the past 25 years (shown in Appendix 2). This implies that as a rural community becomes more developed socially and economically, its residents may exposure to health risks more similar to those experienced by urban people. Consequently, the positive association between urbanization and chronic diseases may not be completely driven by selection bias.

Urbanization is accompanied by pronounced changes in lifestyles. Respondents became more sedentary with an increase in the urbanization index. The mean score of their physical activity was 2.38 out of 5 in 2011, indicating that the overall physical activity intensity of Chinese adults is lower than moderate level (3 points). Their diets are shifting toward high-fat and high-calorie meals. The proportion of calories obtained from fat rose from 21.85 percent in 1991 to 33.59 percent in 2011, exceeding the upper limit (30 percent) recommended by the Chinese DRIs. The changes suggest high risks of obesity and chronic diseases.

Table 2. Prevalence of chronic diseases, urbanization index, calorie intake and physical activity level in each survey year, CHNS

	% Chronic diseases	Urbanization Index	Activity Level[a]	% Calories from Fat	Number of Communities	Number of Observations
1991	2.55	46.16	3.18	21.85	189	7,059
1993	2.32	47.36	3.24	22.65	188	6,558
1997	5.75	52.29	3.07	25.03	190	6,986
2000	8.95	58.43	3.00	27.90	217	6,763
2004	10.46	61.58	2.86	27.61	216	7,236
2006	10.91	63.84	2.84	28.99	218	6,930
2009	14.21	66.89	2.69	30.77	218	7,082
2011	18.16	73.40	2.38	33.59	286	8,744
Total	9.49	59.28	2.89	27.52	306	57,358

[a] Five-point scale with 1=very light and 5=very heavy

Multilevel Poisson Regression Results

To understand how prevalence of diseases varies by urbanization level, we conduct a multilevel Poisson regression analysis (Table 3). Without considering the effects of urbanization, Model 1 in Table 3 shows that a high income is positively associated with a higher risk of chronic diseases. People in the top quintile of the household income distribution are more likely to be diagnosed with chronic diseases than those on low incomes. The predicted odds of developing diseases among them is 7 percent ($e^{0.069} - 1$) higher than that of their low-income counterparts, holding other variables constant. The results suggest that Chinese people become less healthy the more wealth they acquire.[4] The respondents' probability of acquiring chronic diseases is steadily and significantly growing over the survey years (the results are not shown here), suggesting that health risks increase as China becomes more developed.

Model 2 shows that urbanization is associated with a health penalty in China. The effect is both substantial and statistically significant. For every 10-point increase in the urbanization index, the odds of developing chronic diseases get multiplied by 1.128 [($e^{1.206/10}$]. During 2991-2011, the urbanization index increases by 27.24 points on average in all surveyed communities, meaning that rapid urbanization has increased the odds of acquiring non-communicable diseases among Chinese adults by 38 percent. To capture the possible nonlinear effects of urbanization, we classified communities into five categories based on the urbanization index. The results are not significantly different from those presented here. We chose the continuous measurement for ease of interpreting the results. Moreover, the negative effect of high income vanishes after controlling for the influence of urbanization, suggesting that urbanization may account for a greater health decline among higher-income earners.

We further examine whether the SES gradient in health is steepened or flattened by urbanization. Model 3 shows that the income-health relationship differs by urbanization level. The significantly positive coefficient of the cross-level interaction term suggests that high-income living in more urbanized communities are more likely to acquire chronic diseases than high-income earners living in less urbanized areas. For every 10-point increase in the urbanization index, the odds of developing chronic diseases is 5 percent higher for high-income earners [($e^{0.489/10}$ -1]. The results provide evidence for the theory claiming that the SES gradient in health is flattened by urbanization through overweighing the heath advantages of high-SES individuals. One possible explanation is that higher income individuals may adopt more unhealthy lifestyles. We test this hypothesis by constructing three-level growth curve models. The results are shown in Table 4.

[4] The results are consistent when we only focus on high blood pressure, diabetes, myocardial infarction, stroke or transient ischemic attack and asthma.

Table 3. Multilevel Poisson regression coefficients for the effects of urbanization and individual characteristics on chronic diseases

Effects & Variables	Model 1	Model 2	Model 3
Fixed Effects			
<u>Individual-level Predictors</u>			
High Income	0.069*	0.068	-0.002
	(0.035)	(0.045)	(0.055)
Education (ref.=Primary and below)			
Junior high school	0.050	0.023	0.023
	(0.037)	(0.037)	(0.037)
Senior high school	0.059	0.001	-0.004
	(0.043)	(0.044)	(0.044)
Age	0.070***	0.069***	0.069***
	(0.002)	(0.002)	(0.002)
Age^2 *10	0.003*	0.006*	0.004*
	(0.001)	(0.002)	(0.001)
Male	0.194***	0.197***	0.199***
	(0.038)	(0.038)	(0.038)
Married	-0.075	-0.069	-0.069
	(0.051)	(0.051)	(0.051)
Having medical health insurance	0.119**	0.116**	0.122**
	-0.044	-0.042	-0.042
Smoking	(0.037)	(0.037)	(0.037)
	0.003	0.007	0.007
Drinking	(0.035)	(0.035)	(0.035)
	0.181**	0.211***	0.211***
Living in the north	(0.068)	(0.060)	(0.060)
	-0.044	-0.042	-0.042
Intercept	-3.954***	-3.847***	-3.866***
	(0.103)	(0.103)	(0.104)
Survey Year	Yes	Yes	Yes
<u>Community-level Predictor</u>			
Urbanization Index/100		1.206***	1.030***
		(0.142)	(0.161)
<u>Cross-level Interaction</u>			
"Urbanization/100" by "High Income"			0.489*
			(0.209)
Random Effects			
Intercept	0.268***	0.225***	0.228***
Slope		0.126***	0.125***
Number of individuals	57,358	57,358	57,358
Number of communities	309	309	309

Standard errors are in parentheses. ***p<0.001, **P<0.01, *p<0.05,+p<0.1. Respondents in the top quintile of the household income distribution are coded as high income. Urbanization index and age predictors are centered around their respective grand means.

Table 4. Coefficients of three-level growth curve models for correlations between urbanization, individual characteristics and unhealthy lifestyles

Effects & Variables	DV: Calories from Fat		DV: Physical Activity Level	
	Model 1a	Model 1b	Model 2a	Model 2b
Fixed effects				
Individual-level Predictors				
High Income	0.032***	0.017***	-0.165***	-0.084***
	(0.002)	(0.002)	(0.017)	(0.017)
Education (ref.=Primary and below)				
Junior high school	0.024***	0.015***	-0.231***	-0.165***
	(0.001)	(0.001)	(0.010)	(0.010)
Senior high school	0.034***	0.021***	-0.524***	-0.439***
	(0.001)	(0.001)	(0.013)	(0.013)
Age	0.001***	0.001***	-0.014***	-0.010***
	(0.000)	(0.000)	(0.001)	(0.001)
Age^2 $*10^3$	-0.006	-0.007	-0.536***	-0.523***
	(0.004)	(0.004)	(0.000)	(0.000)
Male	-0.013***	-0.011***	0.216***	0.205***
	(0.001)	(0.001)	(0.009)	(0.008)
Married	-0.004*	-0.001	0.046***	0.028*
	(0.001)	(0.001)	(0.013)	(0.012)
Living in the north	-0.033***	-0.028***	0.008	-0.026
	(0.006)	(0.005)	(0.066)	(0.044)
Intercept	0.293***	0.285***	2.816***	2.870***
	(0.005)	(0.004)	(0.053)	(0.038)
Community-level Predictor				
Urbanization Index/100		0.229***		-1.469***
		(0.004)		(0.037)
Random Effects				
Level-1 Within individuals				
Temporal Change	0.009***	0.009***	0.491***	0.489***
Level-2 Individual variation within communities				
Individual intercept	0.001***	0.005***	0.120***	0.116***
Individual changing rate of year $*10^3$	0.002 ***	0.001***	0.288***	0.208***
Individual changing rate of income *10	0.002***	0.005***	0.604***	0.598***
Level-3 Between communities				
Community intercept	0.004***	0.002***	0.542***	0.253***
Community changing rate of year $*10^3$	0.001***	0.001***	0.130***	0.134***
Community changing rate of income	0.001***	0.001***	0.047***	0.045***
% Variance explained:				
By temporal change	7.9%	10.5%	10.4%	10.7%
By individuals	3.2%	3.2%	3.6%	3.6%
By communities		52.5%		64.3%
Number of individuals	57,205	57,205	57,205	57,205
Number of communities	309	309	309	309

Standard errors are in parentheses. ***p<0.001, **P<0.01, *p<0.05,+p<0.1. Respondents in the top quintile of the household income distribution are coded as high income. Urbanization index and age predictors are centered around their respective grand means.

Models 1a and 2a in Table 4 illustrate that higher-SES individuals are more likely to have unhealthy diets and report lower physical activity than their lower-SES counterparts. This may be because people with a higher income are better able to afford certain unhealthy lifestyles, without being fully aware of the potential health risks. For instance, some processed, high-calorie western-style foods such as those served at McDonald's and Pizza Hut are still considered as a symbol of modern life by many middle-class Chinese people, especially residents of small cities and towns. Higher-income earners are better able to afford these diets. The rich may eat at restaurants more often where they take in more calories than they would at home. Moreover, higher-income earners are more likely to be engaged in sedentary work. They may also perform less domestic work and spend less energy on commuting, as they can afford various household appliances and private cars. Their lower level of physical activity puts them at higher risks of obesity and chronic diseases than people of lower SES.

Models 1b and 2b clearly show that high-fat diets and sedentary population tend to be concentrated in more urbanized areas. For every 10-point increase in a community's urbanization index, the residents obtain 2.29 percent more of their calories from fat, and their physical activity score decreases by 0.15. Urbanization accounts for a large proportion of the variation in diets and physical activity intensity across communities. We find that 52.5 percent of the variation in diets and 64.3 percent of the variation in physical activity can be explained by urbanization.

We also examine whether lifestyle is a mechanism through which urbanization influences the SES-health relationship and health outcomes. Model 1 in Table 5 shows that a sedentary lifestyle is positivity associated with disease incidence. If a person adopting a sedentary lifestyle engages in moderate exercise (i.e. the physical activity score increases by two units), his/her odds of developing chronic diseases would be reduced by 25 percent [$1\text{-}(e^{-0.147})^2$]. The magnitude of this effect is substantial. High-fat diets are positively correlated with chronic diseases, but the effect is marginally significant. After controlling for lifestyle measurements, the coefficient of high income reduces by one quarter and becomes insignificant, compared to Model 1 in Table 3. This implies that lifestyles may account for some of the differences in the odds of developing chronic diseases between low- and high- income groups. The goal of Model 3 is to test whether or not the impact of lifestyles varied by urbanization level. The results show that the preventive role of physical activities declines as the community becomes more urbanized. Therefore, the evidence suggests that more health hazards exist in more urbanized areas, and more sophisticated public health programs are needed in these communities.

Table 5. Multilevel Poisson regression coefficients for the effects of urbanization and individual characteristics on diseases: Lifestyle as mediator

Effects & Variables	Model 1	Model 2	Model 3
Fixed Effects			
Individual-level Predictors			
High Income	0.052	0.054	0.060
	(0.035)	(0.045)	(0.045)
Education (ref.=Primary and below)			
Junior high school	0.015	-0.001	-0.004
	(0.037)	(0.037)	(0.037)
Senior high school	-0.022	-0.056	-0.051
	(0.044)	(0.044)	(0.044)
Age	0.068***	0.068***	0.069***
	(0.002)	(0.002)	(0.002)
Age^2	0.001+	0.001+	0.001+
	(0.000)	(0.000)	(0.000)
Male	0.225***	0.223***	0.219***
	(0.038)	(0.038)	(0.038)
Married	-0.065	-0.062	-0.060
	(0.051)	(0.051)	(0.051)
Having medical health insurance	0.092*	0.094*	0.077+
	(0.039)	(0.039)	(0.039)
Physical activity	-0.147***	-0.122***	-0.145***
	(0.015)	(0.016)	(0.016)
% calories for fat	0.240+	0.211	0.224
	(0.136)	(0.137)	(0.153)
Survey Year	Yes	Yes	Yes
Intercept	-3.924***	-3.857***	-3.797***
	(0.102)	(0.103)	(0.104)
Community-level Predictor			
Urbanization Index/100		0.831***	0.988***
		(0.148)	(0.151)
Cross-level Interaction			
“Urbanization/100” by “Physical activity”			0.352***
			(0.076)
“Urbanization/100” by “% calories from fat”			-0.381
			(0.661)
Random Effects			
Intercept	0.207***	0.214***	0.214***
Slope		0.125***	0.127***
Number of individuals	57,358	57,358	57,358
Number of communities	309	309	309

Standard errors are in parentheses. ***p<0.001, **P<0.01, *p<0.05, +p<0.1. Controlled for smoking, drinking, living in the north and survey year fixed effects. Respondents in the top quintile of the household income distribution are coded as high income. Urbanization index and age predictors are centered around their respective grand means.

One interesting observation in Model 3 is that education does not significantly affect the odds of acquiring chronic diseases, although its coefficients are negative. One possible explanation is that it takes time for education to exert its effect. Education can affect health through improving one's health-related knowledge; however, China's rapid urbanization leaves its people with little time to fully grasp the related health risks.

CONCLUSION AND DISCUSSION

The prevalence of "affluent diseases" in China in recent years has received intensive attention. Although numerous studies have speculated about the linkage between rapid urbanization, unhealthy lifestyles, population health and health inequality, the empirical evidence is limited. Using CHNS panel data spanning 20 years, we find a substantial health penalty of urbanization in China. This health penalty is more severe for the higher-income group. Unhealthy diets and low physical activities are important mechanisms through which urbanization affects people's health. The widespread unhealthy lifestyles have even reversed the health benefits associated with improved living standards in urban areas, and suppressed the role of education. China's pace of urbanization may in fact be too rapid for its people to have the time to learn about the health hazards and adjust their lifestyle without being left behind.

The analysis did not include rural to urban migrants. As the CHNS does not collect information about *hukou* type (local vs. non-local *hukou*), it is impossible to differentiate migrants from local residents. Excluding migrants may introduce bias. Younger and healthier people are more likely to migrate than their counterparts, leaving the less healthy and the elderly behind in rural and less urbanized areas. Migrants may return to their hometowns when they get old or become ill. If this is the case, the negative effect of urbanization on health would be underestimated. We are fully aware of the potential bias caused by migration, and thus call for future studies to address this issue.

While we highlight the lifestyle as an important mechanism, other mechanisms exist through which urbanization may influence health. Environmental deterioration is an obvious factor. There is growing concern about the pollution of air, water and solids due to urbanization. Environmental pollution has acute and chronic effects on mortality, morbidity and clinical symptoms (He et al., 2002; Zhu et al., 2011; Ebenstein, 2012). Social psychological factors are also important. For instance, it has been well documented that social cohesion, mutual trust, and social integration are significantly associated with individual health (Browning et al., 2006; Fischer, 1995). Urbanization with poor design, excessive population density and residential segregation may reduce social capital conducive to good health. More efforts are needed to identify how various dimensions of urbanization affect residents' health and well-being.

From a policy perspective, this study suggests an urgent need to design and implement health education and intervention programs to reduce the health risks associated with urbanization. More than US$15.3 billion were invested to treat cardiovascular diseases in 2013 (China National Center for Cardiovascular Diseases, 2015). This expense continues to grow due to the increasing number of patients and rising medical costs. The Chinese government is aiming to further promote urbanization to stimulate domestic demand and economic growth in the coming decades. Against this backdrop, more people will reside in urban settings. Therefore the health cost of urbanization deserves careful evaluation. Hence, social programs to promote healthy lifestyles may be necessary and effective ways to help people stay healthy. In addition, public facilities and green spaces are needed to encourage people to engage in more physical exercise.

References

Allender, S., Foster, C., Hutchinson, L., & Arambepola, C. (2008). Quantification of urbanization in relation to chronic diseases in developing countries: A systematic review. *Journal of Urban Health: Bulletin of the New York Academy of Medicine, 85*(6), 938-951.

Bassuk, S. S., Berkman, L. F., & Amick, B. C. (2002). Socioeconomic status and mortality among the elderly: Findings from four US communities. *American Journal of Epidemiology, 155*(6), 520-533.

Bell, A. C., Ge, K., & Popkin, B. M. (2001). Weight gain and its predictors in Chinese adults. *International Journal of Obesity, 25*(7), 1079-1086.

Cesare, M. D., Khang, Y.-H., Asaria, P., Blakely, T., Cowan, M. J., Farzadfar, F., . . . Ezzati, M. (2013). Inequalities in non-communicable diseases and effective responses. The Lancet, 381(9866), 585-597.

Chen, J., Chen, S., Landry, P. F., & Davis, D. S. (2014). How Dynamics of Urbanization Affect Physical and Mental Health in Urban China. The China Quarterly, 220, 988-1011.

China Nutrition Society (Ed.). (2013). *Chinese DRIs Handbook*. Beijing: China Standards Press.

China National Center for Cardiovascular Diseases (2015). *Report on Cardiovascular Diseases in China 2014.* Beijing: Encyclopedia of China Publishing House.

Cockerham, W. C. (2005). Health lifestyle theory and the convergence of agency and structure. *Journal of Health and Social Behavior, 46*(1), 51-67.

Dahly, D. L., & Adair, L. S. (2007). Quantifying the urban environment: a scale measure of urbanicity outperforms the urban–rural dichotomy. Social Science & Medicine, 64(7), 1407-1419.

Danaei, G., Singh, G. M., Paciorek, C. J., Lin, J. K., Cowan, M. J., Finucane, M. M., et al. (2013). The global cardiovascular risk transition: Associations of four metabolic risk factors with national income, urbanization, and western diet in 1980 and 2008. *Circulation, 127*(14), 1493-1502.

Delisle, H., Ntandou-Bouzitou, G., Agueh, V., Sodjinou, R., & Fayomi, B. (2012). Urbanisation, nutrition transition and cardiometabolic risk: The Benin study. *British Journal of Nutrition, 107*(10), 1534-1544.

Du, S., Mroz, T. A., Zhai, F., & Popkin, B. M. (2004). Rapid income growth adversely affects diet quality in China—particularly for the poor! *Social Science & Medicine, 59*, 1505-1515.

Drewnowski, A., & Popkin, B. M. (1997). The nutrition transition: New trends in the global diet. *Nutrition Reviews, 55*(2), 31-43.

Browning, C. R., Feinberg, S. L., Wallace, D., & Cagney, K. A. (2006). Neighborhood Social Processes, Physical Conditions, and Disaster-Related Mortality: The Case of the 1995 Chicago Heat Wave. *American Sociological Review, 71*(4), 661-678.

Ebenstein, A. (2012). The consequences of industrialization:Evidences from water pollution and digestive cancers in China. *Review of Economics and Statistics, 94*(1), 186-201.

Elo, I. T. (2009). Social class differentials in health and mortality: Patterns and explanations in comparative perspective. *Annual Review of Sociology, 35*, 553-572.

Fang, H., & Rizzo, J. A. (2012). Does inequality in China affect health differently in high- versus low-income households? *Applied Economics*, *44*(9), 1081-1090.

Fischer, C. S. (1995). The subcultural theory of urbanism: A twentieth-year assessment. *American Journal of Sociology*, 543-577.

Gong, P., Liang, S., Carlton, E. J., Jiang, Q., Wu, J., Wang, L., et al. (2012). Urbanisation and health in China. *Lancet, 379,*843-852.

Galea, S., & Vlahov, D. (2005). Urban health: Evidence, challenges, and directions. *Annual Review of Public Health, 26*(1), 341-365.

He, K. B., Huo, H., & Zhang, Q. (2002). Urban air pollution in China: Current status, characteristics, and progress. *Annual Review of Energy and the Environment, 27*, 397-431.

Hu, S., Kong, L., Gao, R., Zhu, M., Wang, W., Wong, Y., et al. (2012). Outline of the Report on Cardiovascular Disease in China, 2010. *Biomedical and Environmental Science, 25*(3), 251-256.

Kim, S., Symons, M., & Popkin, B. M. (2004). Contrasting socioeconomic profiles related to healthier lifestyles in China and the United States. *American Journal of Epidemiology, 159*(2), 186-191.

Li, X., Wang, C., Zhang, G., Xiao, L., & Dixon, J. (2012). Urbanisation and human health in China: Spatial features and a systemic perspective. *Environmental Science and Pollution Research*, 19, 1375–1384.

Link, B. G., & Phelan, J. (1995). Social conditions as fundamental causes of disease. *Journal of Health and Social Behavior*, 35, 80-94.

Luo, W. and Y. Tong. (2016). Educational Disparities in Access to Health Insurance in China, 1989–2009, *Chinese Sociological Review* 48(2), 137-161

Jones-Smith, J. C., & Popkin, B. M. (2010). Understanding community context and adult health changes in China: Development of an urbanicity scale. *Social Science & Medicine, 71*(8), 1436-1446.

Ma, L. J. C. (2002). Urban transformation in China, 1949-2000: a review and research agenda. *Environment and Planning A, 34*(9), 1545-1569.

Maruapula, S. D., Jackson, J. C., Holsten, J., Shaibu, S., Malete, L., Wrotniak, B., et al. (2011). Socio-economic status and urbanization are linked to snacks and obesity in adolescents in Botswana. *Public Health Nutrition, 14*(12), 2260-2267.

McDade, T. W., & Adair, L. S. (2001). Defining the "urban" in urbanization and health: a factor analysis approach. Social Science & Medicine, 53(1), 55-70.

National Health and Family Planning Commission of the People's Republic of China (2013). *China Health Statistical Yearbook 2012*.

Ng, S. W., Norton, E. C., & Popkin, B. M. (2009). Why have physical activity levels declined among Chinese adults? Findings from the 1991-2006 China health and nutrition surveys. *Social Science & Medicine, 68*(7), 1305-1314.

Pampel, F. C., Krueger, P. M., & Denney, a. J. T. (2010). Socioeconomic disparities in health behaviors. *Annual Review of Sociology, 36*, 349-370.

Popkin, B. M., Monda, K. L., Gordon-Larsen, P., & Stevens, J. (2007). China's transition: The effect of rapid urbanization on adult occupational physical activity. *Social Science & Medicine, 64*(4), 858–870.

Raudenbush, S. W., & Bryk, A. S. (2002). Hierarchical linear models: Applications and data analysis methods (Vol. 1): Sage.

Robert, S. A. (1999). Socioeconomic position and health: The independent contribution of community socioeconomic context. *Annual Review of Sociology, 25*(1), 489-516.

Robert, S. A., & House, J. S. (2000). Socioeconomic inqualities in health: An enduring sociological problem. In C. E.Bird, P. Conrad, A. Fremont & S. Timmermans (Eds.), *Hand Book of Medical Sociology* (5th ed.). NJ: Prentice Hall.

Smith, K. V., & Goldman, N. (2007). Socioeconomic differences in health among older adults in Mexico. *Social Science & Medicine, 65*(7), 1372-1385.

Sodjinou, R., Agueh, V., Fayomi, B., & Delisle, H. (2008). Obesity and cardio-metabolic risk factors in urban adults of Benin: Relationship with socio-economic status, urbanisation, and lifestyle patterns. *BMC Public Health, 8*, 84-97.

Van de Poel, E., O'Donnell, O., & Van Doorslaer, E. (2007). Are urban children really healthier? Evidence from 47 developing countries. Social Science & Medicine, 65(10), 1986-2003.

Van de Poel, E., O'Donnell, O., & Van Doorslaer, E. (2009). Urbanization and the spread of diseases of affluence in China. *Economics & Human Biology, 7*(2), 200-216.

Van de Poel, E., O'Donnell, O., & Van Doorslaer, E. (2012). Is there a health penalty of China's rapid urbanization? *Health Economics, 21*(4), 367-385.

Vlahov, D., & Galea, S. (2002). Urbanization, urbanicity, and health. *Journal of Urban Health: Bulletin of the New York Academy of Medicine, 79*(4), S1-12.

Vlahov, D., Gibble, E., Freudenberg, N., & Galea, S. (2004). Cities and health: History, approaches, and key questions. *Academic Medicine, 79*(12), 1133-1138.

Wen, M., Hawkley, L. C., & Cacioppo, J. T. (2006). Objective and perceived neighborhood environment, individual SES and psychosocial factors, and self-rated health: An analysis of older adults in Cook County, Illinois. *Social Science & Medicine, 63*(10), 2575-2590.

Yang, W., & Kanavos, P. (2012). The less healthy urban population: Income-related health inequality in China. *BMC Public Health, 12*, 804-816.

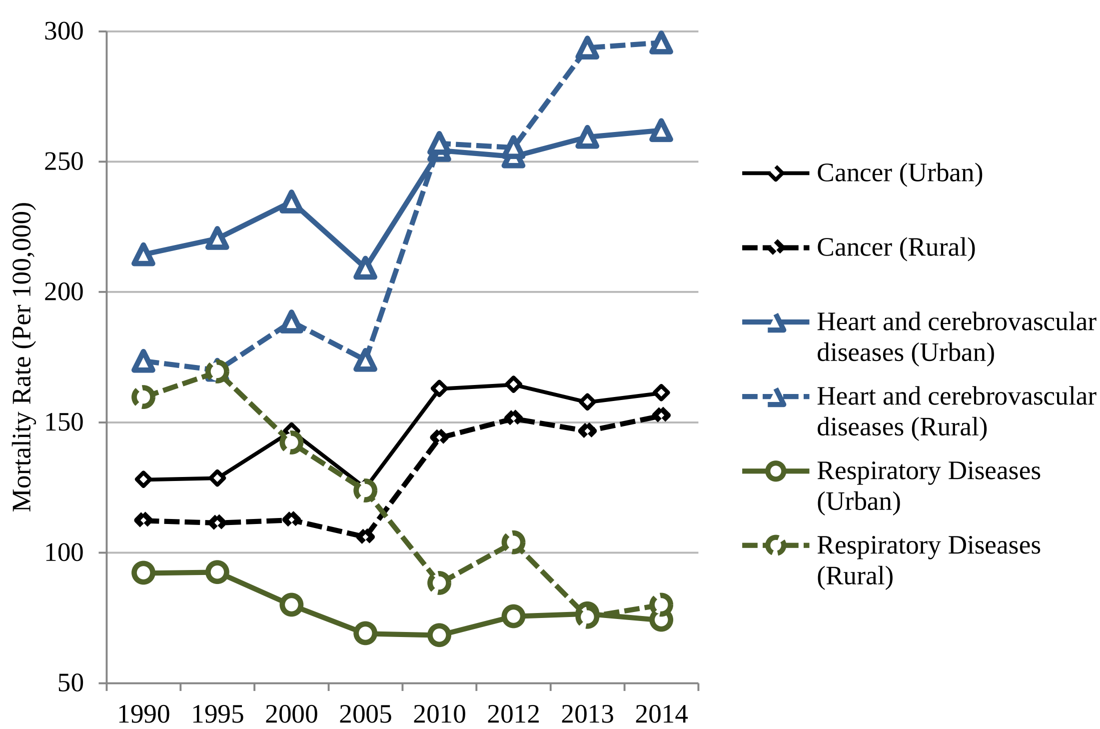
Zhu, Y.-G., Ioannidis, J. P. A., Li, H., Jones, K. C., & Martin, F. L. (2011). Understanding and Harnessing the Health Effects of Rapid Urbanization in China. *Environmental Science & Technology, 45*(12), 5099-5104.

Appendix 1. Chronic disease prevalence (%) among Chinese people by age group and urbanization level, CHNS 1991-2011

	Urbanization index			
Age group	16-40	41-60	61-80	81-106
18-24	1.10	2.41	2.44	4.10
	(15%)	(12%)	(11%)	(8%)
25-34	1.50	2.18	2.54	4.87
	(23%)	(21%)	(23%)	(19%)
35-44	3.11	5.00	6.89	8.58
	(28%)	(29%)	(28%)	(28%)
45-54	6.65	11.72	16.18	24.93
	(24%)	(27%)	(26%)	(30%)
55-60	13.15	19.23	25.86	40.72
	(10%)	(11%)	(13%)	(15%)
Total	4.27	7.55	10.20	17.42
	(100%)	(100%)	(100%)	(100%)
N	12,467	18,992	14,289	11,610

Note: Percentages of respondents in each age group are in parentheses.

Appendix 2. Mortality from the top three major causes of death in China during 1990-2014, by rural-urban residence. Source: China Health and Family Planning Statistical Yearbooks.



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