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Research Article

Association Between Urbanicity and Dementia in China: A Population-Based Study

Yanan Luo, PhD,[1,2] Yihao Zhao, MD,[1,3] Lihua Pang, PhD,[1,3] Chao Guo, PhD,[1,3] Richard Liang, BS,[4] and Xiaoying Zheng, PhD[1,3,*]

[1]Institute of Population Research, Peking University, Beijing, China. [2]Advanced Systems Analysis, International Institute for Applied Systems Analysis, Laxenburg, Austria. [3]APEC Health Science Academy, Peking University, Beijing, China. [4]School of Medicine, Stanford University, California.

*Address correspondence to: Xiaoying Zheng, PhD, Peking University, No. 5 Yiheyuan Road Haidian District, Beijing 100871, P.R. China. E-mail: xzheng@pku.edu.cn

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Abstract

Objectives: This study investigated the relationship between urbanicity and dementia and predicted its nonlinear pattern among Chinese adults aged 50 years and older.

Methods: This study used data from the Second National Sample Survey on Disability, which was implemented from April 1 to May 31, 2006 across China. Dementia status was determined by a 2-stage process: the combination of self-reports or family members' reports and an onsite medical diagnosis by experienced specialists based on the International Statistical Classification of Diseases and Related Health Problems 10th Revision Symptom Checklist for Mental Disorders. Logistic regression models were used to examine the relationship between urbanicity and dementia, and restricted polynomial spline regression models were plotted to examine the nonlinear exposure–response relationship of urbanicity and dementia.

Results: Logistic regression results showed that an increase of 10% in the degree of urbanization was associated with a 73% decrease in the odds of dementia after adjusting for covariates, particularly area-level socioeconomic variables. This observed association was stronger in the younger age group, and this age group difference was only present in women. Spline regression findings suggested a nonlinear exposure–response relationship between urbanicity and the odds of dementia. Areas with very high levels of urbanization were associated with increased odds of dementia.

Conclusions: These findings highlight the necessity to properly examine the nuanced relationship between urbanicity and mental health, especially for women in the younger age group. Notably, there were increased odds of dementia at very high levels of urbanicity.

Keywords: Dementia, Nonlinear relationship, Urbanicity

Dementia is one of the most disabling health issues and continues to be an increasing global health challenge (Ferri et al., 2005). Around the world, 46.8 million people suffered from dementia in 2015, and more than 131.5 million people are expected to be affected by 2050 (Alzheimer's Disease International, 2015). Dementia typically affects a person's cognitive functioning and activities of daily living, which places a heavy burden on dementia patients, their families, and society (Shah et al., 2016). The annual global cost of dementia is US$ 818 billion, and this is expected to increase substantially in the next few decades (Alzheimer's Disease International, 2015). In China, the estimated total cost of dementia was US$ 47.2 billion in 2010 and will increase by more than twofold to US$ 114.2 billion by 2030

(Xu et al., 2017). With the rapid population aging, China has seen dementia become an urgent public health concern.

Urbanicity is one of the most well-established risk factors for mental disorders. While decades of research present an association between mental disorders and urbanicity (DeVylder et al., 2018), urbanicity has both risks and benefits to health (Dye, 2008). Exposure to urbanicity, or the various attributes associated with urbanization, may lead to incremental increases in wealth, but the rapid expansion of urban centers may also result in densely populated areas, higher rates of poverty, poorer living conditions, increased inequalities in the allocation of public services, and more environmental pollution (Dye, 2008; Vlahov et al., 2007).

Increasing aging and rapid urbanization have been subjects of interest in the growing literature on the relationship between urbanicity and cognitive health. Most evidence suggests an inverse relationship between urbanization and dementia, with higher urbanicity relating to a lower likelihood of developing dementia (Lorenzo-López et al., 2017). However, there is some evidence that residence in areas with a high degree of urbanization is related to greater exposure to pollution, which results in a higher risk of dementia (Robbins et al., 2019). Especially residents in areas with extremely high levels of urbanization, overpopulation, and crowding are associated with reduced cognitive control and impaired spatial memory, which increase the risk of dementia (Cassarino et al., 2018).

China has experienced an unprecedented scale of urbanization in recent decades, offering substantial opportunities for both health improvements and health risks. Studies about rural–urban variations in cognition in China indicate a higher prevalence of dementia and poor cognitive function in rural areas, as compared with urban areas (Jia et al., 2014; Xu et al., 2019). However, few studies have examined the exposure–response association or the nonlinear relationship between urbanicity and dementia, which has significant public health implications. By using a large, nationally representative data set, this study investigated the relationship between urbanicity and dementia and predicted its nonlinear pattern among Chinese adults aged 50 years and older. This study will fill the gaps in knowledge of the relationship between urbanicity and dementia.

Method

Study Population

This study used data from the Second National Sample Survey on Disability, which was implemented from April 1 to May 31, 2006 across China. The objectives of this survey were to describe the prevalence, causes, and severity of a disability, as well as the living conditions and health service demands of the disabled population. Multistage, stratified random-cluster sampling with probability proportional to size was used in 734 counties (districts), 2,980 towns (streets), and 5,964 communities (villages) from 31 provinces to select 2,526,145 noninstitutionalized individuals in mainland China. The samples in this study represented 1.9 per 1,000 noninstitutionalized inhabitants of China. Additional details on the design and sample processing of this survey have been previously published (Zheng et al., 2011).

More than 20,000 interviewers, 50,000 survey assistants, and 6,000 doctors of various specialties were involved with this survey. Face-to-face household interviews were conducted to investigate every family member in the selected households (Li et al., 2015). If the interviewees were cognitively impaired or did not have the ability to answer the questionnaire, their respective questions were answered by one of their family members. Designated specialists conducted further disability screenings and confirmed diagnoses for those who responded "yes" to any of the relevant questions in the structured questionnaire.

In this study, we restricted our final analysis to 688,507 participants aged 50 years or older because cases of dementia often begin after 50 years of age (Logue et al., 2019).

Ethical Approval

The Second National Sample Survey on Disability was approved by the State Council of China and was conducted in each province by the Leading Group of the National Sample Survey on Disability and the National Bureau of Statistics. All survey respondents provided consent to the Chinese government.

Measurements

Dementia

Dementia status was determined by the combination of self-reports or family members' reports and an onsite medical diagnosis by experienced specialists (World Health Organization, 2001). First, trained interviewers, who were recruited from local primary care institutions, screened persons aged 50 years and older by using a structured questionnaire with five items during the household face-to-face interview process. This questionnaire was developed according to the "Guidelines and Principles for the Development of Disability Statistics" recommended by the United Nations (United Nations, 2001), which has demonstrated high reliability (Zhang, 2010). The five items include (1) Has a poor memory (forgetful)?; (2) Has difficulty in concentration (his/her mind often wanders)?; (3) Has difficulty controlling their emotions (moody, too joyful, or too joyless)?; (4) Has strange language and/or weird behavior that could not be understood or accepted by a normal person?; and (5) Drinking alcohol on an empty stomach (for at least 5 times per week) or hypnotic drug overdose (Liu et al., 2014). Participants who answered "yes" to the previous questions were considered cases with a suspected psychiatric disability. Second, specialists with more than 5 years of clinical experience identified psychiatric disability by using the World Health Organization Disability Assessment Schedule, Version II (WHO DAS II) in suspected cases (World Health Organization, 1999). Individuals who received WHO DAS scores of at least 52 were defined as having a psychiatric disability (Liu et al., 2014). Third, psychiatrists conducted face-to-face interviews with those individuals and made diagnoses of dementia based on the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10) Symptom Checklist for Mental Disorders (World Health Organization, 1992).

Urbanicity

Degree of urbanization at the county level was used in this study to assess the degree of urbanicity, which was measured as the ratio of nonagricultural population to the total population (%). According to the urbanization curve suggested by Northam, urbanization is divided into three stages: an initial stage (degree of urbanization <25%), an accelerating stage (25% ≤ degree of urbanization ≤ 70%), and a terminal stage (degree of urbanization >70%; Northam, 1979). To establish this measure, data on the size of both nonagricultural and total populations were obtained from 734 counties in the 2000 China census, which was subsequently linked to participants' addresses in the Second National Sample Survey on Disability.

Covariates

Individual-level covariates in this study included age (continuous variable), sex (male/female), marital status (married/single), education attainment (primary school and below, junior high school, and senior high school and above), and household income per capita (divided into tertiles, from lowest (1) to highest (3) household income per capita).

Area-level covariates included socioeconomic status and Gini index, which may be moderating factors for the association between urbanicity and dementia. Area-level socioeconomic status was estimated by summing up the *z*-scores of the following measures: per capita income, percentage of residents with high school education, percentage of residents with income below the poverty line (reverse-coded), and percentage of residents with upper-class occupation (including manager and technical staff positions). This measure of area-level socioeconomic status had a mean of zero, standard deviation (*SD*) of 1, and a range from −2.83 to 3.05. Higher values reflected higher area-level socioeconomic status. Gini index was calculated using the distribution of income across income percentiles in a population. A higher Gini index indicates greater inequality, with high-income individuals representing a greater proportion of the total income of the population. Gini index in this study was divided into three categories: no inequality of income (Gini index <0.3), some inequality of income (Gini index 0.3–0.4), and large inequality of income (Gini index >0.4). These two county-level indicators were also calculated by using data from 734 counties in the 2000 China census, which was linked to study participants' addresses.

Statistical Analysis

This study used logistic regression models to examine the relationship between urbanicity and dementia among adults aged 50 years and older, allowing for multiple demographic and socioeconomic covariates. In addition, restricted polynomial splines with knots at the 20th, 45th, 60th, and 80th percentiles for the degree of urbanization were plotted to examine the nonlinear exposure–response relationship of urbanicity and dementia. A p value of less than .05 was considered statistically significant. The software Stata version 13.0 for Windows (Stata Corp, College Station, TX) was used for statistical analysis.

Results

Characteristics of Participants

As presented in Table 1, the mean age of dementia patients (mean = 72.88, *SD* = 10.60) was greater than the mean age of people without dementia (mean = 62.07, *SD* = 9.56). Participants in the dementia group were more likely to be female, less likely to be married, and had lower education attainment, as compared with the group without dementia. At the area level, dementia patients tended to reside in areas with higher degrees of urbanization, higher Gini index, and higher area-level socioeconomic status.

Prevalence of Dementia

The prevalence of dementia was higher in women (0.26%) than in men (0.19%). Unmarried participants (0.51%) had a higher prevalence of dementia than married participants (0.15%). The group with the lowest income tertile and the group with education attainment of primary school and below had the highest prevalence of dementia within their corresponding categories (0.26% and 0.41%, respectively). The prevalence of dementia was higher in the older than 85 years group (older age group) than in the 50–84 years group (younger age group), and this difference was greater in women than in men (Table 2). Supplementary Figure 1 shows the relationship between the prevalence of dementia and the degree of urbanization among adults aged 50 years and older. As the degree of urbanization incrementally increased, the prevalence of dementia also increased.

Table 1. Characteristics of Participants Aged 50 Years and Older (*N* = 688,507)

Characteristic	With dementia, %/mean (*SD*)	Without dementia, %/mean (*SD*)
Area level		
Degree of urbanization, mean (*SD*)	44.80 (33.46)	40.10 (31.41)
Area-level socioeconomic status	0.29 (1.22)	0.018 (1.00)
Gini index		
<0.3	119 (7.73)	73,135 (10.65)
0.3~0.4	1,022 (66.41)	435,289 (63.36)
>0.4	398 (25.86)	178,544 (25.99)
Individual level		
Sex		
Male	638 (41.46)	339,873 (49.47)
Female	901 (58.54)	347,095 (50.53)
Age, years, mean (*SD*)	72.88 (10.60)	62.07 (9.56)
Married status		
Married	814 (52.89)	545,179 (79.36)
Unmarried	725 (47.11)	141,789 (20.64)
Household income per capita		
Tertile 1 (lowest)	591 (38.40)	229,868 (33.46)
Tertile 2	401 (26.06)	198,142 (28.84)
Tertile 3 (highest)	547 (35.54)	258,958 (37.70)
Education		
Primary school and below	922 (59.91)	226,498 (32.97)
Junior high school	404 (26.25)	253,595 (36.92)
Senior high school and above	213 (13.84)	206,875 (30.11)

The Association Between Urbanicity and Dementia

Table 3 presents the logistic regression results of the association between urbanicity and dementia. Model 1 (unadjusted) shows that participants in areas with a higher degree of urbanization had an increased odds of dementia among adults older than 50 years (odds ratio [OR] = 1.98, 95% confidence interval [CI]: 1.65–2.38). However, after adjusting for area-level socioeconomic status (Model 2), the association between urbanicity and the odds of dementia became reversed, with an OR of 0.29 (95% CI: 0.19–0.39). As Model 3 presents, the OR of the degree of urbanization was further decreased after adjusting for the Gini index. Every increase of 10% in the degree of urbanization was associated with a 73% decrease in the odds of dementia.

This study also examined whether urbanicity interacted with age and found age differences in the association between the degree of urbanization and the odds of dementia. The protective effect of the degree of urbanization was diminished in the older age group (older than 85 years) but not in the younger age group (50–84 years). This difference was only significant in women (Table 4).

Figure 1 shows that the exposure–response relationship between the degree of urbanization and dementia was nonlinear. At low and middle levels of urbanization, the OR of dementia remained below 1 with incremental changes in the degree of urbanization. However, in areas with an extremely high degree of urbanization, incremental changes in the degree of urbanization were associated with increased odds of dementia.

Discussion

In this large population-based study, there was a nonlinear exposure–response relationship between the degree of urbanicity and the odds of dementia. Although a higher degree of urbanization was associated with a lower prevalence of dementia among Chinese adults aged 50 years and older, after adjusting for covariates, an increased odds of dementia was found among participants who resided in areas with very high levels of urbanization.

To the best of our knowledge, this is the first study to examine the odds of dementia in association with exposures to urbanicity among the Chinese population. The present study is consistent with previous studies that have linked urbanicity with dementia or cognitive function in high-income countries, such as England (Wu et al., 2017), the United States (Weden et al., 2018), Canada (Chen et al., 2017; Helmes & Van Gerven, 2017), and Ireland (Cassarino et al., 2016, 2018). These studies found that people living in urban areas were less likely to develop dementia or cognitive decline as compared with those in rural areas. And those living in medium to very high urban areas were found to have better cognitive functioning than those living in areas with low urbanization (Cassarino et al., 2018). Geographical isolation and limited accessibility to resources may also be mediating factors between

Table 2. Prevalence of Dementia (%) Among Participants Aged 50 Years and Older

Characteristics	Total	50–84 years	85+ years
Total	0.22	0.19	1.62
Married status			
Married	0.15	0.14	1.34
Unmarried	0.51	0.40	1.68
Household income per capita			
Tertile 1 (lowest)	0.26	0.23	1.15
Tertile 2	0.20	0.18	1.31
Tertile 3 (highest)	0.21	0.17	2.51
Education			
Primary school and below	0.41	0.34	1.64
Junior high school	0.16	0.15	1.54
Senior high school and above	0.10	0.09	1.65
Female	0.26	0.21	1.76
Married status			
Married	0.15	0.14	1.78
Unmarried	0.56	0.43	1.76
Household income per capita			
Tertile 1 (lowest)	0.28	0.25	1.09
Tertile 2	0.24	0.20	1.36
Tertile 3 (highest)	0.25	0.19	3.10
Education			
Primary school and below	0.41	0.33	1.64
Junior high school	0.15	0.13	2.40
Senior high school and above	0.09	0.07	3.36
Male	0.19	0.17	1.35
Married status			
Married	0.15	0.14	1.17
Unmarried	0.41	0.35	1.47
Household income per capita			
Tertile 1 (lowest)	0.23	0.21	1.27
Tertile 2	0.16	0.15	1.19
Tertile 3 (highest)	0.17	0.15	1.57
Education			
Primary school and below	0.41	0.36	1.61
Junior high school	0.17	0.16	1.18
Senior high school and above	0.11	0.10	1.00

urbanicity and dementia. For example, residents in rural areas or areas with a low degree of urbanicity have fewer opportunities to access medical and financial resources than residents in areas with higher urbanicity (Fors et al., 2009). This may contribute to a higher risk of dementia in less urban areas.

Our results showed an increased odds of dementia in areas with very high degrees of urbanization. Several mechanisms may support our findings. First, the poor built environment and overcrowded living conditions may be detrimental to cognitive function in regions with a very high degree of urbanization (Wu et al., 2017). In Chinese megacities, many citizens struggle because of high real estate prices, overcrowded environments, and unfavorable living conditions (Bettina & Petra, 2015), which all pose significant mental health risks (Simmel, 1950). Second, although areas with very high urbanicity may have high levels of socioeconomic status due to rapid economic growth, the rapid economic growth may cause serious environmental problems, such as air pollution and traffic-related pollution. Therefore, residents in areas with very high levels of urbanization may have greater exposure to pollutants, which is associated with a higher risk of developing dementia (Attademo & Bernardini, 2017; Chen et al., 2017). Our results regarding the moderating role of area-level socioeconomic status on the association between urbanicity and dementia may support this possible mechanism. That is, higher area-level socioeconomic status may have been driving the initial increased odds of dementia. So, after adjusting for area-level socioeconomic status, higher urbanicity was then associated with decreased odds of dementia. Third, areas with high levels of urbanization may experience widening inequality, which leads to many stressors to its residents. These chronic

Table 3. Logistic Regressions of the Association Between Degree of Urbanization and Dementia

Characteristics	Model 1	Model 2	Model 3
Degree of urbanization, 10%	1.98 (1.65–2.38)	0.29 (0.20–0.42)	0.27 (0.19–0.39)
Area-level socioeconomic status		2.07 (1.85–2.33)	2.12 (1.89–2.38)
Gini index			
<0.3			Reference
0.3~0.4			1.31 (1.08–1.59)
>0.4			1.47 (1.19–1.80)
Sex			
Male	Reference	Reference	Reference
Female	0.93 (0.83–1.04)	0.91 (0.81–1.02)	0.91 (0.81–1.02)
Age, years	1.09 (1.08–1.09)	1.08 (1.08–1.09)	1.08 (1.08–1.09)
Married status			
Married	Reference	Reference	Reference
Single	1.24 (1.10–1.39)	1.25 (1.11–1.41)	1.25 (1.11–1.41)
Household income per capita			
Tertile 1 (lowest)	Reference	Reference	Reference
Tertile 2	0.95 (0.83–1.08)	0.86 (0.75–0.98)	0.88 (0.77–1.00)
Tertile 3 (highest)	1.03 (0.89–1.18)	0.78 (0.67–0.91)	0.79 (0.68–0.92)
Education			
Primary school and below	Reference	Reference	Reference
Junior high school	0.65 (0.57–0.74)	0.63 (0.55–0.72)	0.63 (0.55–0.72)
Senior high school and above	0.45 (0.37–0.54)	0.40 (0.33–0.48)	0.40 (0.33–0.48)

Table 4. Logistic Regressions of the Association Between Degree of Urbanization and Dementia, by Sex

Characteristics	Total	Female	Male
Degree of urbanization, 10%	0.23 (0.16–0.34)	0.20 (0.12–0.32)	0.29 (0.16–0.52)
Age group, years			
50–84	Reference	Reference	Reference
85+	0.73 (0.55–0.98)	0.62 (0.43–0.88)	0.87 (0.52–1.46)
Degree of urbanization, 10% × Age group, years			
Degree of urbanization, 10% × 50–84	Reference	Reference	Reference
Degree of urbanization, 10% × 85+	1.81 (1.18–2.78)	2.06 (1.22–3.48)	1.51 (0.69–3.26)

Note: All models adjusted by area-level socioeconomic status, Gini index, sex, age (continuous), marital status, household income per capita, and education.

stressors found in urban environments can negatively affect cognitive function in old age (Krupat, 1985). Areas in China with a very high degree of urbanization see tremendous social inequality between the rich elite and the working poor. A study from the United Nations presented that the Gini coefficients of several big cities in China were higher than that of most other cities in East Asia, with Shenzhen standing highest at 0.49 (United Nations Human Settlements Programme, 2010). The moderating effect of the Gini index on urbanicity and dementia relationship may support this mechanism, in a similar manner as area-level socioeconomic status.

We also found that the association between urbanicity and the risk of dementia was stronger in the younger age group than in the older age group, and this age group difference was only present in women. The oldest adults are more likely to be "left-behind elderly" and live in remote rural areas in China, which may not benefit from urbanicity. Decreased social support and lower socioeconomic conditions among women in China may result in the gender difference found in the moderating role of age. For example, a previous study found female cognitive disadvantage in China (Xu et al., 2019). Women who were living in rural areas or were rural-to-rural migrants may have fewer opportunities to engage in social activities and expand their social connections outside of the household. This may explain why our study found that women had the highest prevalence of dementia.

Limitations

This study is the first to explore the nonlinear association between urbanicity and the odds of developing dementia by using a nationally representative population-based sample in China. However, this study is not without limitations. First, due to the cross-sectional nature of this study, the casual relationship between urbanicity and dementia remains uncertain. The reverse causation association

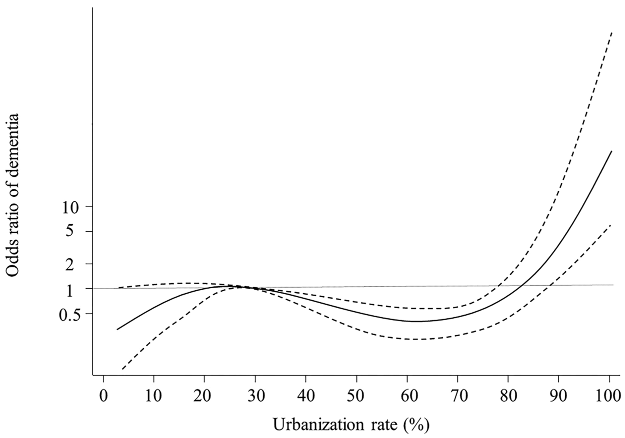

Figure 1. The relationship between the odds ratio of dementia and the degree of urbanization.

resulting from people with dementia moving to cities after the onset of their disorder cannot be excluded. Further studies are needed to understand additional details about the causal mechanism between urbanicity and dementia. Second, urbanicity can be closely related with other factors that may be associated with dementia, such as pollution and living environments; due to a lack of data, we were not able to explore this association. Third, due to restrictions of the survey design, the level of urbanicity was assessed at the county level, rather than the settlement level, and was based on population counts, rather than residential density. Therefore, the results of this study should be interpreted with caution. Future investigations with expanded data and longitudinal design will be needed to address these limitations.

Conclusions

This study found that higher degrees of urbanization were associated with lower odds of dementia among Chinese adults aged 50 years and older. While urbanicity was initially associated with increased odds of dementia, adjustment for area-level socioeconomic variables reversed the direction of this association, such that urbanicity was actually associated with decreased odds of dementia. This observed association was stronger in the younger age group than in the older age group, and this age group difference was only present in women. Moreover, this study found a nonlinear exposure–response relationship between the degree of urbanicity and the odds of dementia. Areas with very high levels of urbanization were associated with increased odds of dementia. Future studies will need to explore the etiology and mechanism of this relationship. These findings suggest that it is necessary to properly examine the nuanced relationship between urbanicity and mental health, especially for women in the younger age group. Notably, the odds of dementia were decreased at lower levels of urbanicity and increased at very high levels of urbanicity.

Supplementary Material

Supplementary data are available at *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences* online.

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Author Contributions

Y. N. Luo: study concept and design, drafting the manuscript, data analysis, interpretation, and revision of the article. Y. H. Zhao, L. H. Pang, C. Guo, and R. Liang: revision of the article. X. Y. Zheng: critical revision of the article for important intellectual content. All authors gave final approval of the version to be published.

Conflict of Interest

None declared.

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