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Article

Journal of Aging and Health
2018, Vol. 30(8) 1319–1344
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DOI: 10.1177/0898264317715975
journals.sagepub.com/home/jah
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The Long Arm of Childhood in China: Early-Life Conditions and Cognitive Function Among Middle-Aged and Older Adults

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Abstract

Objective: This study examined the association between childhood conditions and cognitive function among middle-aged and older adults in China. **Method:** We analyzed data from the 2011 China Health and Retirement Longitudinal Study (N = 11,868). Cognitive function was measured by word recall, a test of episodic memory. We examined the association between childhood conditions and cognitive function among the middle-aged (45-59 years) and the older (60 years and older) adults separately, using multilevel linear regressions. **Results:** Indicators of childhood socioeconomic status (SES) and nutrition were significantly associated with memory performance among the middle-aged and the older adults in China. Adulthood SES, education in particular, accounted for some but not all the associations. The protective effect of childhood urban residence was stronger for middle-aged women than for middle-aged men. **Discussion:** Childhood conditions are

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significantly associated with mid- to late-life cognitive function in China. The strengths of the associations may vary by gender and cohort.

Keywords
cognitive function, China, childhood condition, education, CHARLS

Cognitive function is an important component of health and well-being. It encompasses the mental abilities to acquire and process information, apply knowledge, plan, and manage the demands of daily living (Richards & Deary, 2014). Low cognitive function is significantly associated with disability, increased demands for medical and personal care, and premature death among older people (Institute of Medicine, 2015; Langa et al., 2001; Obisesan & Gillum, 2009). Until recently, much of the research on late-life cognitive function has focused on the influence of mid- and late-life factors such as adulthood socioeconomic status (SES), social relationships, chronic diseases, and lifestyles (Andel, Silverstein, & Kareholt, 2015; Lee et al., 2010; Zunzunegui, Alvarado, Del Ser, & Otero, 2003). However, increasingly, research suggests that childhood conditions such as parental SES may play an important role in late-life cognitive function (McEniry, 2013; Richards & Deary, 2005; Richards & Wadsworth, 2004). Most of this research has been carried out in Europe and North America. Much less is known about the effects of early-life circumstances on cognitive function among middle-aged and older adults in rapidly aging developing countries such as China.

China has undergone dramatic social and economic developments in the past few decades. Many middle-aged and older Chinese today had an impoverished childhood and experienced widespread social unrest and upheaval when growing up. As adults, they lived through the economic reforms in the 1980s and 1990s, which have significantly improved their standards of living (Chen, Yang, & Liu, 2010). In contrast, very few cohorts in developed countries have experienced such significant social and economic changes over the lifecourse. Therefore, China is an interesting setting to investigate the association between childhood conditions and mid- to late-life cognition.

Drawing on the 2011 baseline survey of the China Health and Retirement Longitudinal Study (CHARLS), we examined the association between childhood conditions and cognitive function among Chinese adults in mid- (ages 45-59 years) and late life (ages 60 years and older). We extend prior research by investigating multiple dimensions of childhood conditions, including SES, health, and nutrition simultaneously. In addition, we explored whether the association between childhood conditions and cognitive function varied by gender and cohort in China.

Childhood Conditions and Cognitive Function in Later Life

Previous research has pointed to three important childhood factors—SES, nutrition, and health—that may influence cognitive function in later life (Scazufca et al., 2008; Zeng, Gu, & Land, 2007; Zhang, Gu, & Hayward, 2010).

Childhood SES is the one most frequently investigated, often measured by father's education, father's occupation, poverty, and rural residence (e.g., Fors, Lennartsson, & Lundberg, 2009; Scazufca et al., 2008; Wen & Gu, 2011; Zhang, Gu, & Hayward, 2008). A few studies have also included mother's education as an indicator (González, Tarraf, Bowen, Johnson-Jennings, & Fisher, 2013; Horvat et al., 2014; Luo & Waite, 2005). Overall childhood SES has been found to be positively associated with mid- and late-life cognitive function in the United States, United Kingdom, Sweden, and Eastern Europe (Fors et al., 2009; Horvat et al., 2014; Luo & Waite, 2005; Richards & Wadsworth, 2004). For example, using the British 1946 birth cohort, Richards and Wadsworth (2004) found that exposure to poor material home conditions (e.g., poor repair, old house, uncleanliness, crowding) was strongly associated with lower cognitive abilities in childhood and adolescence, and the effects persisted into midlife. In the United States, higher childhood SES measured by parental education and father's occupation was positively associated with global cognitive functioning among older adults ages 50 years and older (Luo & Waite, 2005). Similarly, having a father classified as a manual worker in childhood was associated with lower cognitive scores in old age in Sweden (Fors et al., 2009). A few studies in western countries found that both father's and mother's education were positively associated with children's late-life cognitive function (Glymour, Tzourio, & Dufouil, 2012; González et al., 2013). It is suggested that mothers' education may be particularly important in early life because they are the main caregivers of children, and their educational level has direct effect on children's cognitive development and health, which, in turn, influences educational and occupational achievements in adulthood, both of which are related to late-life cognition (Rogers et al., 2009).

Research in China on the effect of childhood SES on cognitive function in later life is sparse but illuminating. Higher childhood SES, measured by urban residence and father having a white-collar job, was associated with a lower risk of cognitive impairment among Chinese adults ages 65 years and older (Wen & Gu, 2011; Zhang et al., 2010). As far as we know, no study has examined how parental education may affect late-life cognition in China. Because the general education level was very low, and most women were

illiterate in the early 20th-century China, we investigated whether limited years of parental schooling was associated with better cognitive function in later life, net of other childhood factors.

Regarding childhood nutritional status, the findings are relatively consistent. Several studies in the United States, South Korea, and China have shown that early nutritional deprivation (e.g., indicated by frequent hunger, limb length, and head circumference) was associated with increased risks of cognitive impairment and dementia in old age (Haan & Wallace, 2004; T. L. Huang et al., 2008; Kim et al., 2008; Zhang et al., 2010; see Barnes et al., 2012 for an exception). On the contrary, better childhood nutrition (measured by height, leg length, and daily milk drinking) has been found to be positively associated with late-life cognitive function in the United States, China, Latin America, and the Caribbean (Case & Paxson, 2008; Heys et al., 2009; Maurer, 2010; Zhang et al., 2009).

Fewer studies have examined the association between childhood health and late-life cognition, due to a lack of data on childhood health. One study in the United States found that respondents' retrospective report of childhood health was significantly associated with global cognitive function in old age (Luo & Waite, 2005). In China, it was found that never/rarely suffering from serious illness during childhood significantly reduced the risk of cognitive impairment in people ages 80 years and older (Zeng et al., 2007). However, Zeng et al.'s study focused on the oldest old, which is a highly selective age group, and their findings cannot be generalized to middle-aged and older Chinese.

Possible Explanations for the Association Between Childhood Condition and Cognitive Function in Later Life

Explanations for the association between childhood conditions and late-life cognition have largely been offered from two perspectives—the latency model and the pathway model (Hertzman, 1999; Lyu & Burr, 2016). The latency model suggests that early-life circumstances have a *direct* association with late-life cognitive function. Early-life adversities such as poverty, undernutrition, serious illnesses, and abuse can affect brain maturation during childhood and adolescence (Lyu & Burr, 2016; Ritchie et al., 2011). Impaired development of the brain early in life can result in a brain that functions less efficiently because of "less myelin, less branching of dendrites, and less developed connectivity patterns" (Moceri, Kukull, Emanuel, van Belle, & Larson, 2000, p. 415). Animal studies suggest that malnutrition could damage specific regions of the brain, such as the hippocampus, a region important for learning and memory (Abbott et al., 1998). Even a small degree of

hippocampal damage can affect cognitive performance (Hertzman, 1999). The negative effects of impaired brain development due to early-life adversities may be small until aggravated by the aging process (Haan & Wallace, 2004; Moceri et al., 2000). According to this perspective, early-life adversity should be associated with poor cognitive function even after controlling for adulthood factors because some negative effects of childhood adversity on cognition can be irreversible.

The pathway model suggests that early-life circumstances have an *indirect* effect on late-life cognition. Childhood adversity often has negative impacts on educational achievement and occupation in adulthood. Education has been considered one of the major determinants of cognitive reserve; adult occupation provides cognitive practice that is conducive to the development and maintenance of cognitive abilities (National Research Council, 2000). In addition, poor childhood conditions can significantly increase the risk of chronic diseases (e.g., hypertension, heart disease, and stroke) in adulthood, which, in turn, affects cognitive function in old age (O'Rand & Hamil-Luker, 2005; Turrell et al., 2002). According to this perspective, the association between childhood adversity and late-life cognitive function should be greatly attenuated when adulthood SES and health are controlled for. It is important to point out that these two models are not mutually exclusive, and late-life cognition may be influenced by both processes.

Research so far has found evidence to support both perspectives, although the extent to which adult SES can explain the association between childhood factors and late-life cognition varies by country and the type of childhood factors examined. Adulthood SES was found to mediate a significant portion (more than 50%) of the association between childhood conditions (e.g., SES and nutrition) and cognitive function in the United States and European countries (Case & Paxson, 2008; Luo & Waite, 2005; Singh-Manoux, Richards, & Marmot, 2005). Studies in China, however, report that adulthood SES explained very little of the effects of childhood SES and nutritional deprivation on late-life cognitive impairment (Wen & Gu, 2011; Zhang et al., 2010). This may suggest potential differences in the mechanisms linking childhood conditions and late-life cognition between China and developed countries. For instance, we may find stronger support for the latency model in China than in the developed countries due to the more severe nature of childhood disadvantages and the lack of schooling opportunities in China.

Gender and Cohort Variations

Considering the historical and cultural contexts in China, we believe that it is important to explore gender and cohort variations in the association between

childhood conditions and mid- to late cognition. Due to the permeation of patriarchy in Chinese society for centuries, the current cohorts of middle-aged and older women, especially those in rural areas, were disadvantaged throughout their lives compared with men (Croll, 1983; Pearson, 1995). For example, in a family with multiple children, sons were often favored and given better food than daughters in the past (Watson, 1991). In addition, girls had much fewer opportunities for pursuing education and mentally stimulating occupations than boys. Therefore, childhood conditions may have stronger effects on late-life cognition for women than for men because women had relatively fewer sources and less power to escape an impoverished childhood. One study that looked at the oldest old (ages 80 years and older) in China found that the effect of advantaged childhood was more protective for older women in terms of the risk of cognitive impairment (Zhang et al., 2008).

Cohort is another important variable that needs to be considered when we examine the association between childhood conditions and cognition in later life. Different cohorts experienced different historical events or the same events but at different life stages and may have carried different imprints of those experiences in later life. For example, social, political, economic, and health conditions were very different before and after 1949, the year when the People's Republic of China (PRC) was established. For the older cohort who grew up during the early half of the 20th century, many experienced Japanese invasion, civil wars, hunger, and malnutrition in their childhood (Whyte, 1999; Zhang et al., 2008). Previous studies found that more than 60% of older Chinese ages 65 years and older reported that they frequently went to bed hungry in childhood (Zhang et al., 2010). The estimated life expectancy was below 30 years in the 1920s and reached 36 years in the 1940s (Adlakha & Banister, 1995; Kantha, 1990). Educational opportunities were limited to those who could afford, and 80% of the population were illiterate in 1949 (Hannum, 1999). Against this backdrop, disadvantaged childhood conditions should be significantly associated with poor late-life cognition for the older cohort born before the establishment of PRC.

The relationship between childhood conditions and adulthood cognitive function was more complicated for those who grew up in Maoist China (1950s-1970s). On one hand, the standard of living improved and mortality declined significantly in that era (except during the 1959-1961 Great Leap Forward Famine) relative to the decades prior, and life expectancy reached 50 years in 1957 and about 60 years in the years 1964 to 1982. The communist government aimed to eliminate privileges of the upper class, reduce social inequality, and create a "classless" and egalitarian society (Chen et al., 2010; Hannum & Xie, 1994). During the early 1950s and the Cultural Revolution (1966-1976), children whose fathers were poor peasants and

laborers were favored relative to those whose fathers were landlords, capitalists, and intellectuals when it came to access to higher education and good jobs (Whyte, 1999; Zhang et al., 2009). The Cultural Revolution also greatly undermined the quality of education and severed the link between education and occupational achievement for those entering adolescence and young adulthood (Hannum, 1999). The drastic actions by the communist government to create an equalitarian society lead us to think that the association between childhood conditions and adult cognition may be weaker for the cohort growing up in the 1950s to 1970s (who are now middle-aged) than for the older cohort.

Only one regional study in China has examined cohort differences in the association between childhood SES and cognitive function (Zhang et al., 2009). The findings supported the hypothesis that the association between childhood SES and adulthood cognitive function varied by cohorts. Specifically, for those born before 1949, father's higher occupational status (professional vs. laborer) was associated with higher cognitive functioning; but for those born after 1949, the pattern was reversed. However, the study participants were born in Beijing, a major city, and it was not clear whether such patterns existed in other parts of China.

The Present Study

Our study contributes to the current debate on early-life influences on cognitive function in later life in three ways. First, by focusing on China, we provide a context very different from Western nations to examine the association between childhood conditions and late-life cognition. Chinese middle-aged and older adults, compared with their counterparts in the United States, have endured a much harsher life in their childhood. Hunger, malnutrition, wars, and social upheavals were common experiences for many ordinary Chinese during most of the 20th century up until the economic reforms in the late 1970s (Whyte, 1999; Zhang et al., 2008). Such disadvantaged childhood may have left an indelible mark on adulthood cognitive functioning, and adulthood SES, although important in influencing cognitive function in later years, may not completely account for the association between childhood conditions and late-life cognition.

Second, previous studies on China have relied heavily on very selective samples (e.g., urban, hospital, and the oldest old), and it is difficult to assess the generalizability of the findings. CHARLS is the first nationally representative data of those ages 45 years and older in China and collected information on childhood conditions including both father's and mother's education, rural/urban residence, childhood health, and knee length. Seldom have these

factors been examined simultaneously in China, and our study will shed light on the independent contributions of these important childhood factors to late-life cognition.

Third, we investigate whether the relationship between childhood conditions and cognition function varies by gender and cohort. Our older group (ages 60 years and older) was born in 1951 or before, and our middle-aged group (ages 45 and 59 years) was born between 1952 and 1966. Although previous literature has suggested that gender and cohort may be moderators of the relationship between childhood conditions and cognition, few studies have tested these hypotheses.

Based on previous research, we hypothesize that (a) childhood SES, nutrition, and health are associated with cognitive function and (b) adulthood SES and health would partially account for the association. We also explored whether the association between childhood conditions and cognitive function varied by gender and cohort.

Data and Method

Data

We drew on data from the 2011 baseline survey of the CHARLS. The CHARLS is modeled after the Health and Retirement Study in the United States. It is a nationally representative longitudinal survey of community-dwelling adults ages 45 years and older in China, who are interviewed every 2 years. If the respondents were married, their spouses were also interviewed. A multistage cluster sampling method was used to obtain the final sample, which included 17,708 respondents from 150 counties in 28 provinces in China. Face-to-face computer-assisted personal interviews were conducted, with a response rate of 80.5%. In addition, 13,974 respondents (78.9%) provided anthropometric and physical performance measures (Smith, Tian, & Zhao, 2013; Zhao, Smith, & Strauss, 2014). Our analytic sample is restricted to respondents ages 45 years and older who took part in the memory tests and provided anthropometric and physical performance measures ($N = 11,868$).

Measures

Cognitive function. In the adult population, cognition is usually assessed by psychometric test scores in memory, executive function, processing speed, vocabulary, and visuospatial skills (Richards & Deary, 2014). In this article, we focused on the domain of memory. Research has shown that memory is

crucial for reasoning and daily functioning and "highly sensitive to brain changes in the early stages of Alzheimer's disease" (Lachman, Agrigoroaei, Murphy, & Tun, 2010; Weir, Lay, & Langa, 2014). Respondents were asked to recall 10 simple Chinese nouns right after they were read to them (immediate recall) and then 4 minutes later (delayed recall). Following previous research, we averaged the scores of immediate recall and delayed recall to create a measure of episodic memory (W. Huang & Zhou, 2013; Lei, Smith, Sun, & Zhao, 2013). In additional analysis, we used immediate recall and delayed recall, respectively, as a dependent variable in separate models and the results were similar.

Childhood conditions. We examined childhood conditions in three broad categories—childhood SES, childhood health, and childhood nutrition.

Childhood SES was measured by father's education (1 = *1 or more years of schooling*), mother's education (1 = *1 or more years of schooling*), and childhood residence (1 = *urban*) up to age 16 years. We dichotomized parental education because the majority of the respondents' parents had no schooling at all. There is a deep rural–urban divide in China. Rural residents in China had much lower standards of living and more limited opportunities for education, employment, and healthcare than their urban counterparts in the early- and mid-20th century when the CHARLS respondents were born and raised, and therefore childhood residence reflects the overall individual as well as community socioeconomic conditions of the respondents as they grew up (Whyte, 1999; Zeng et al., 2007; Zimmer & Kwong, 2004).

Childhood health was based on the respondent's rating of his or her health before age 16 years on a 5-point scale ranging from poor to excellent. Previous research in the United States suggested that general assessment of childhood health has reasonably good reliability and validity (Haas, 2007). Childhood nutrition was indicated by knee height, an anthropometric measure that reflects nutritional or other deficits in childhood (Huang et al., 2008; Maurer, 2010).

Adulthood SES. Adulthood SES was measured by education, receipt of wage and bonus in the past year, pension benefit, and household assets. Education was coded into five categories—illiterate, less than elementary but can read and write, elementary school, middle school, and high school or more. Receipt of wage and bonus reflected the respondents' employment status in nonagricultural occupations. Pension benefit was measured as a dummy variable. Household assets were measured by a count of luxury items that the household owned (e.g., refrigerator, washing machine, TV, computer, cell phone) from a list of 17 items (Li, Liu, Zhang, & Xu, 2015).

Adulthood health. We used three indicators of adulthood health—chronic disease, functional limitation, and activities of daily living (ADL) disability. Chronic disease was coded as a dummy variable. Respondents were classified as either having one or more of the following four diseases or having none—hypertension, heart disease, stroke, and diabetes. Except for hypertension, coding of each chronic disease classification rested on respondents' answers to the question of whether a doctor had ever told them that they had that particular condition. Prior studies have shown that a significant proportion of older adults in China were not aware of having hypertension (Feng, Pang, & Beard, 2014), so we supplemented the self-report with blood pressure (BP) data collected by the CHARLS team. Each respondent's systolic and diastolic BPs were measured three times by a trained nurse. Hypertension was coded as 1 if a respondent had a high mean systolic BP or a mean diastolic BP that reached the clinical cutoff point (systolic BP ≥140 mmHg or diastolic BP ≥90 mmHg), or had been diagnosed with hypertension, and 0 otherwise. Functional limitation was coded as 1 if the respondent had difficulty doing any of the following seven activities—walking 1 km; getting up from a chair after sitting for a long period; climbing several flights of stairs without resting; stooping, kneeling, or crouching; reaching arms above shoulders; carrying 10 pounds; or picking up a small coin from a table, and it was coded as 0 otherwise. *Disability* was coded as 1 if the respondent reported having difficulty performing one or more of the following five activities independently for at least 3 months—bathing, dressing, eating, getting into or out of bed, or using the toilet.

Other covariates. We included respondent's age and age-squared, gender (1 = *female*), marital status (1 = *currently married*), and a dummy variable indicating whether parents' education was reported by his or her spouse, which was the case when the respondent was not available to answer the question.

Analytic Strategies

We first calculated weighted descriptive statistics of the study variables for the whole sample and the two cohorts. Then, we did separate analysis for the middle-aged (45-59 years) and the older group (60 years and older) because previous research has shown that the effect of childhood SES on cognition differed by cohort in China (Zhang et al., 2009), and our preliminary analysis showed a statistically significant three-way interaction (childhood urban × female × cohort). For each cohort, multilevel linear regressions with robust standard errors were used to examine the association between childhood conditions and cognitive function. We used multilevel modeling to account for correlations within households and communities because

some of our respondents came from the same household or the same community. The first model included childhood conditions and control variables, and then adulthood SES and health were added sequentially to examine whether the association between childhood conditions and cognitive function attenuates with these adulthood variables added. Finally, we added interaction terms between each childhood variable and gender into our full model, one at a time. Only statistically significant interactions were included in the final tables.

Overall, there were very few missing data for the independent variables. To reduce the influence of missing items on our data analysis and inferences, we used multiple imputation. The results were based on 10 random, multiple-imputed replicates. We conducted all analyses using Stata 14.

Results

Sample Characteristics

Table 1 presents the distributions of all study variables. On average, the sample respondents recalled 3.5 words out of 10. Only about 9.2% grew up in an urban area. Parental education levels were low: Approximately 10.2% of respondents had a mother who received some education, and 36.1% had a father who had some education. The mean of childhood health is 3.26, and the mean knee height is 47.97 cm.

Regarding adulthood SES, about 26.79% of the respondents were illiterate; 18.44% attended but did not finish elementary school, whereas 22.33% finished elementary school, 21.13% received a middle school education, and only about 11.31% completed high school education or above. About 16.28% of respondents received wages and bonuses, and 19.37% had pension. Household assets averaged about four luxury items.

In terms of adulthood health, about 47.16% of respondents had one or more chronic diseases, 54.02% had at least one functional limitation, and about 14.15% had difficulty performing ADL. The mean age of respondents was 59.31 years, and 85.85% were currently married. Among the unmarried, 82.6% were widowed (results not shown). As for the differences between the middle-aged and the older group, we found that the middle-aged group did better on the memory test (3.84 vs. 3.08) than the older group. The former also had slightly longer knees. A larger proportion of the middle-aged respondents had parents who had some education. In terms of adulthood SES, the middle-aged were better educated and had more household assets than the older group. As expected, a higher proportion of the middle-aged received wages and bonus, and a lower proportion had pensions and health problems, which partly reflected the different life stage of the two groups.

Table 1. Weighted Descriptive Statistics of Chinese Adults Ages 45 Years and Older, CHARLS, 2011.

	Total (*N* = 11,868)	Ages 45-59 years (N = 6,559)	Ages 60+ years (N = 5,309)
Episodic memory (0-10)	3.50 (0.04)	3.84 (0.04)	3.08 (0.04)
Childhood conditions			
Grew up in urban area (%)	9.20	9.88	8.41
Mother had 1+ years of schooling (%)	10.21	14.68	4.64
Father had 1+ years of schooling (%)	36.12	42.08	28.69
Childhood health (1-5)	3.26 (0.02)	3.28 (0.03)	3.24 (0.03)
Knee height (cm)	47.97 (0.06)	48.14 (0.07)	47.75 (0.08)
Adulthood SES			
Education (%)			
Illiterate	26.79	19.28	36.14
Less than elementary school	18.44	16.62	20.70
Elementary school	22.33	20.00	25.25
Middle school	21.13	28.41	12.06
High school and above	11.31	15.69	5.85
Received wage and bonus past year (%)	16.28	24.33	6.24
Pension (%)	19.37	6.41	35.52
Household assets	4.14 (0.06)	4.69 (0.07)	3.44 (0.06)
Adulthood health			
Any chronic diseases (%)	47.16	37.51	59.19
Any functional limitations (%)	54.02	46.19	63.78
Any ADL disability (%)	14.15	9.05	21.12
Control variables			
Age (years)	59.31 (0.17)	52.20 (0.07)	68.17 (0.14)
Female (%)	51.82	53.50	49.72
Currently married (%)	85.85	93.20	76.68
Parents' education reported by spouse (%)	21.32	24.15	17.80

Note. Values in parentheses are standard errors of means. CHARLS = China Health and Retirement Longitudinal Study; SES = socioeconomic status; ADL = activities of daily living.

Childhood Conditions and Episodic Memory Among Middle-Aged Chinese (Born Between 1952 and 1966)

Table 2 presents the results of a series of regression models for episodic memory among the middle-aged Chinese. Model 1 included all indicators of childhood conditions and control variables. We found that all indicators of

Table 2. Multilevel Linear Regression Analysis on Episodic Memory Among Chinese Adults Between Ages 45 and 59 Years, CHARLS, 2011 (n = 6,559).

	Episodic memory					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Childhood conditions						
Grew up in urban area (rural)	0.611 (0.091)**	0.333 (0.087)**	0.303 (0.088)**	0.610 (0.092)**	0.313 (0.090)**	0.162 (0.109)
Mother had 1+ years of schooling (no schooling)	0.351 (0.060)**	0.244 (0.058)**	0.217 (0.058)**	0.342 (0.060)**	0.214 (0.058)**	0.213 (0.058)**
Father had 1+ years of schooling (no schooling)	0.223 (0.042)**	0.111 (0.042)**	0.093 (0.042)*	0.216 (0.042)**	0.090 (0.042)*	0.090 (0.042)*
Childhood health	0.035 (0.019)	0.019 (0.018)	0.009 (0.018)	0.028 (0.018)	0.007 (0.018)	0.007 (0.018)
Knee height	0.017 (0.007)*	0.012 (0.006)	0.010 (0.006)	0.018 (0.007)**	0.011 (0.006)	0.011 (0.006)
Adulthood SES						
Education (illiterate)						
Less than elementary school		0.335 (0.064)**	0.308 (0.064)**		0.313 (0.064)**	0.306 (0.064)**
Elementary school		0.641 (0.072)**	0.595 (0.072)**		0.596 (0.071)**	0.586 (0.072)**
Middle school		1.065 (0.065)**	1.004 (0.065)**		1.001 (0.065)**	0.988 (0.065)**
High school and above		1.518 (0.077)**	1.402 (0.079)**		1.390 (0.078)**	1.374 (0.078)**
Received wage and bonus past year (no wage and bonus)			0.114 (0.049)*		0.101 (0.049)*	0.104 (0.049)*
Pension (no pension)			0.111 (0.093)		0.092 (0.092)	0.056 (0.096)
Household assets			0.078 (0.011)**		0.074 (0.011)**	0.075 (0.011)**

(continued)

Table 2. (continued)

	Episodic memory					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Adulthood health						
Any chronic diseases (none)				−0.112 (0.037)**	−0.128 (0.036)**	−0.126 (0.036)**
Any functional limitations (none)				−0.176 (0.043)**	−0.109 (0.042)*	−0.106 (0.042)*
Any ADL disability (none)				−0.269 (0.069)**	−0.178 (0.067)**	−0.177 (0.067)**
Grew up in urban area × female						0.291 (0.122)*
Covariates						
Age	−0.050 (0.005)**	−0.025 (0.005)**	−0.022 (0.005)**	−0.044 (0.005)**	−0.018 (0.005)**	−0.018 (0.005)**
Age-squared	0.003 (0.001)*	0.006 (0.001)**	0.006 (0.001)**	0.003 (0.001)*	0.006 (0.001)**	0.006 (0.001)**
Female (male)	−0.112 (0.044)*	0.186 (0.046)**	0.173 (0.047)**	−0.061 (0.046)	0.206 (0.048)**	0.179 (0.049)**
Currently married (unmarried)	0.253 (0.087)**	0.169 (0.085)*	0.108 (0.087)	0.244 (0.087)**	0.104 (0.087)	0.110 (0.087)
Parents' education reported by spouse (self-report)	−0.120 (0.047)*	−0.085 (0.046)	−0.108 (0.046)*	−0.133 (0.046)**	−0.117 (0.045)**	−0.115 (0.045)*
Constant	3.667 (0.053)**	2.809 (0.072)**	2.841 (0.073)**	3.798 (0.057)**	2.950 (0.075)**	2.972 (0.076)**
Individual-level variance	2.032 (0.066)	1.936 (0.062)	1.933 (0.062)	2.035 (0.066)	1.935 (0.062)	1.933 (0.062)
Household-level variance	0.320 (0.058)	0.244 (0.055)	0.228 (0.055)	0.297 (0.058)	0.214 (0.055)	0.216 (0.055)
Community-level variance	0.328 (0.040)	0.308 (0.038)	0.296 (0.038)	0.320 (0.039)	0.294 (0.037)	0.293 (0.037)

Note. Unstandardized regression coefficients and (robust standard errors) are presented. Continuous variables are centered at their means. The results are based on 10 multiple-imputed data sets. CHARLS = China Health and Retirement Longitudinal Study; SES = socioeconomic status; ADL = activities of daily living.
*$p < .05$. **$p < .01$.

childhood SES were significantly associated with episodic memory, net of control variables. Respondents who grew up in urban areas and whose mothers and fathers had some education had better memory than those who spent their childhood in rural areas and had parents who did not have any schooling. In addition, knee height was positively associated with memory. Surprisingly, the association between childhood health and memory was not statistically significant, net of other childhood factors and control variables.

In Model 2, we added education of the respondents, and the results showed that education was strongly associated with memory in midlife. The estimates for childhood urban residence, mother's education, and father's education were reduced by 45.5% ([0.611 − 0.333]/0.611 × 100%), 30.5%, and 50.2%, respectively, but remained statistically significant, with the addition of education. The coefficient of knee height was also reduced and became statistically insignificant. We then added three additional indicators of adulthood SES—wage receipt, pension benefit, and household assets—in Model 3. Having more household assets and having received wages were significantly associated with better memory, but pension benefit was not. Compared with those in Model 2, the coefficients for childhood residence, mother's education, and father's education were reduced slightly but remained statistically significant. These results thus suggest that education was the primary factor accounting for the effects of childhood conditions on memory in midlife.

To examine the role of adulthood health in the association between childhood conditions and memory, in Model 4, we added three indicators of health conditions to Model 1. As is shown, chronic disease, functional limitations, and ADL disability were significantly associated with poorer memory. However, the results barely changed compared with those in Model 1, suggesting that health conditions did not account for the association between childhood conditions and memory function among middle-aged Chinese.

Model 5 is the full model which included all indicators of childhood conditions, adulthood SES and health, and control variables. The results showed that childhood urban residence, father's education, and mother's education were independently associated with better memory, controlling for other childhood and adulthood variables in the model.

Finally, we tested whether the association between childhood conditions and memory varied by gender in Model 6. We found one significant interaction (childhood urban × female): Growing up in urban areas had stronger protective effects for women's memory than for men's in midlife, after controlling for other childhood factors and adult SES and health. As shown in Model 6, for middle-aged men, the coefficient of childhood urban residence was no longer statistically significant after we added the childhood urban

interaction by gender. In contrast, we found that childhood urban residence was still significantly associated with memory among middle-aged women in additional analysis (results not shown). Specifically, even after controlling for parental education, childhood health, knee height, adulthood SES and health conditions, and other covariates, middle-aged women who grew up in urban areas recalled 0.453 more words than their counterparts who grew up in rural areas.

Childhood Conditions and Episodic Memory Among Older Chinese (Born in 1951 or Before)

Table 3 shows the results of the association between childhood conditions and cognitive function for older adults in China. We followed the same analytic procedures as we did for middle-aged adults. There are similarities as well as some notable differences compared with the results for the middle-aged adults. First, among those ages 60 years and older, childhood urban residence, mother's education, father's education, and knee height were significantly associated with memory in the base model (Model 1). However, childhood health was not significantly associated with memory. These results were very similar to the results among the middle-aged.

Second, education explained a significant portion of the positive effects of childhood urban residence (51.7%), father's education (49.8%), and mother's education (no longer statistically significant) but a smaller portion of the effects of knee height (18.2%), as shown in Model 2. With the additional adulthood SES indicators added in Model 3, the coefficients of childhood residence, father's education, and knee height became slightly smaller but remained statistically significant. Compared with Model 1, the results of Model 3 thus suggest that adulthood SES as a whole explained about 60.5% of the difference in memory by childhood residence and 55.1% of the difference by father's education.

Third, similar to the results for the middle-aged, we found that adding adult health conditions did not explain much of the association between childhood conditions and memory performance, although each health variable was significantly associated with memory performance (Model 4). Looking across the models from Model 1 to Model 4, we conclude that education was the primary factor accounting for the association between childhood conditions and memory.

Finally, we did not find any significant interactions between indicators of childhood conditions and gender among those ages 60 years and older (results not shown). All childhood variables had similar effects on late-life memory for older men and women. Specifically, older men and women growing up in

Table 3. Multilevel Linear Regression Analysis on Episodic Memory Among Chinese Adults Ages 60 Years and Older, CHARLS, 2011 (n = 5,309).

	Episodic memory				
	Model 1	Model 2	Model 3	Model 4	Model 5
Childhood conditions					
Grew up in urban area (rural)	0.603 (0.098)**	0.291 (0.094)**	0.238 (0.095)*	0.566 (0.097)**	0.220 (0.095)*
Mother had 1+ years of schooling (no schooling)	0.228 (0.114)*	0.117 (0.107)	0.101 (0.107)	0.219 (0.114)*	0.099 (0.107)
Father had 1+ years of schooling (no schooling)	0.303 (0.050)**	0.152 (0.047)**	0.136 (.047)**	0.291 (0.050)**	0.131 (0.046)**
Childhood health	0.034 (0.020)	0.028 (0.020)	0.025 (0.020)	0.027 (0.020)	0.020 (0.020)
Knee height	0.022 (0.007)**	0.018 (0.007)**	0.017 (0.007)*	0.024 (0.007)**	0.019 (0.007)**
Adulthood SES					
Education (illiterate)					
Less than elementary school		0.387 (0.059)**	0.374 (0.059)**		0.375 (0.059)**
Elementary school		0.746 (0.061)**	0.717 (0.061)**		0.701 (0.061)**
Middle school		1.148 (0.074)**	1.096 (0.075)**		1.074 (0.074)**
High school and above		1.584 (0.093)**	1.471 (0.097)**		1.437 (0.096)**
Received wage and bonus past year (no wage and bonus)			−0.026 (0.084)		−0.056 (0.085)
Pension (no pension)			0.172 (0.052)**		0.159 (0.052)**
Household assets			0.046 (0.011)**		0.042 (0.011)**

(continued)

Table 3. (continued)

	Episodic memory				
	Model 1	Model 2	Model 3	Model 4	Model 5
Adulthood health					
Any chronic diseases (none)				0.101 (0.041)*	0.061 (0.040)
Any functional limitations (none)				−0.256 (0.048)**	−0.201 (0.047)**
Any ADL disability (none)				−0.197 (0.054)**	−0.157 (0.054)**
Covariates					
Age	−0.057 (0.004)**	−0.049 (0.004)**	−0.048 (0.004)**	−0.054 (0.004)**	−0.046 (0.004)**
Age squared	−0.001 (0.000)*	−0.000 (0.000)	−0.000 (0.000)	−0.001 (0.000)*	−0.000 (0.000)
Female (male)	−0.137 (0.046)**	0.154 (0.047)**	0.145 (0.048)**	−0.085 (0.048)	0.179 (0.049)**
Currently married (unmarried)	0.123 (0.059)*	0.068 (0.057)	0.050 (0.057)	0.122 (0.059)*	0.051 (0.057)
Parents' education reported by spouse (self-report)	−0.220 (0.058)**	−0.172 (0.055)**	−0.173 (0.056)**	−0.217 (0.057)**	−0.171 (0.055)**
Constant	3.121 (0.048)**	2.491 (0.060)**	2.462 (0.065)**	3.241 (0.055)**	2.586 (0.071)**
Individual-level variance	1.777 (0.059)	1.726 (0.059)	1.721 (0.059)	1.769 (0.057)	1.710 (0.057)
Household-level variance	0.323 (0.055)	0.238 (0.054)	0.233 (0.054)	0.308 (0.055)	0.229 (0.054)
Community-level variance	0.312 (0.041)	0.260 (0.034)	0.253 (0.033)	0.300 (0.040)	0.249 (0.033)

Note. Unstandardized regression coefficients and (robust standard errors) are presented. Continuous variables are centered at their means. The results are based on 10 multiple-imputed data sets. CHARLS = China Health and Retirement Longitudinal Study; SES = socioeconomic status; ADL = activities of daily living.
*$p < .05$. **$p < .01$.

urban areas, had longer knees, and had fathers who had some schooling showed better memory performance, net of mother's education, childhood health, adult SES and health, and other covariates (Model 5).

In additional analyses (results not shown), we assessed the extent to which childhood conditions and adulthood SES accounted for the total variance of memory in two cohorts by estimating two additional models (i.e., an unconditional model and a model with demographic and other controls). We found that among the middle-aged adults, childhood conditions explained about 5.3% of the total variance in memory, and adulthood SES explained an additional 7.6%. Among the older adults, childhood conditions and adulthood SES explained about 4.6% and 7.5% of the total variance in memory, respectively. To put these statistics in perspective, for example, we found that among the middle-aged, demographic and other controls explained 2.7% and adult health explained 0.4% of the variance in memory.

Discussion

Using data collected from a nationally representative sample of adults ages 45 years and older in China, we assessed the hypotheses that indicators of childhood SES, health, and nutrition were associated with episodic memory in mid- and late life, and that the association would be attenuated after controlling for adulthood SES and health. We also tested gender differences in the association between childhood conditions and cognitive function in the two cohorts—the middle-aged and the older adults, respectively.

We found relatively strong support for our first hypothesis as indicators of childhood SES and childhood nutrition were significantly associated with episodic memory, net of controls, for both men and women in the two cohorts. Specifically, childhood urban residence, father's education, mother's education, and knee height emerged as robust predictors of memory performance. However, childhood health was not significantly associated with memory in either cohort.

The relative strong effects of childhood residence on episodic memory in middle- and old age deserve further discussion. China began implementing a household registration system (*hukou*), which classified all citizens into "agricultural" (rural) or "nonagricultural" (urban) *hukou*, in the late 1950s. Although the system was originally developed to restrict rural-to-urban migration, it has become the most important stratification system in China for the past six decades. The life chances of urban and rural residents were vastly different because the Chinese state siphoned off resources in the rural sector for industrial development in cities, allocated its budget disproportionately to urban residents, and set up institutional barriers to social mobility of its rural

residents (Chan, 2009; Cheng & Seldon, 1994; Wu & Treiman, 2004). From cradle to grave, urban residents enjoyed a broad range of privileges including food rations, education, employment, subsidized housing, medical care, disability pay, and retirement pensions, whereas rural residents were provided little (Whyte, 1999). Although the restrictions on rural-to-urban migration have been gradually eased since the economic reforms in the late 1970s, it remains difficult to change *hukou* status from rural to urban (Wu & Treiman, 2004). Thus, childhood residence and the associated *hukou* system become one of the major determinants of multiple socioeconomic resources (e.g., nutrition, education, employment) in China (Liu, Rizzo, & Fang, 2015), which, in turn, affect one's cognitive function in adulthood. Our finding not only adds to a small but growing literature that linked childhood rural residence with poor late-life cognition (Contador, Bermejo-Pareja, Puertas-Martin, & Benito-Leon, 2015; Hall, Gao, Unverzagt, & Hendrie, 2000; Nguyen, Couture, Alvarado, & Zunzunegui, 2008) but also shows the particular importance of childhood residence in the Chinese context.

We found that education explained a substantial portion of the advantages associated with childhood urban residence in memory performance, whereas measures of more current economic status and health did not explain much of the link between childhood residence and memory. In addition, one's own educational attainment also partly explained the association between parental education and cognitive functioning. These findings are consistent with a growing body of research that suggests that education is one of the major mechanisms linking childhood SES and late-life cognitive function (Case & Paxson, 2008; Kaplan et al., 2001).

Furthermore, our results suggest that it is important to take gender and cohort into consideration when we examine the association between childhood conditions and adulthood cognition in China. We found that childhood urban residence was more protective for middle-aged women than for middle-aged men in terms of memory. We speculate that this may be partly due to the social changes that happened after the PRC was established in 1949 and the actions of the communist government to improve gender equality in both public and domestic spheres (Croll, 1983; Hannum & Xie, 1994). Chinese girls in urban areas may have benefited more from these social changes and had more opportunities to go to schools and work in mentally stimulating jobs than girls in rural areas (Lavely, Xiao, Li, & Freedman, 1990).

Surprisingly, despite growing up in very different political and economic contexts, the association between parental education and memory was significant in both the middle-aged and the older adult groups. Children with more educated parents were more likely to have higher educational attainment, which contributed to better cognitive functioning.

Likewise, knee height was significantly associated with memory in both groups. However, the mechanisms linking knee height and memory seemed to differ between the two groups. We found that in the middle-aged group, knee height was no longer statistically significant after education was controlled for, suggesting that adults who were undernourished in childhood may have lower levels of education, which then led to poorer memory in midlife. Therefore, much of the effect of childhood nutrition appeared to be indirect among the middle-aged Chinese, supporting the pathway model. In the older adult group, much of the association between knee height and memory remained unexplained after we added adulthood SES and health, suggesting a much more permanent and independent effect of malnutrition on late-life cognition. It is unclear why the pathways seemed different for the two cohorts. One explanation is that members of the older age group may have experienced more severe nutritional deprivation during childhood and for a longer duration than the middle-aged group due to the different historical contexts. Consequently, the damage to brain development may be more serious for the older cohort compared with the younger cohort. More research is needed to explore other explanations for this intriguing finding.

In conclusion, we found that even after adjusting for adulthood SES and health, the associations of paternal education, maternal education (for the middle-aged group), childhood residence (except for middle-aged men), and knee height (for the older adult group) with episodic memory were statistically significant. Some of our results are consistent with the latency model. Nevertheless, we advise caution in interpreting these findings because the observed associations between childhood conditions and cognitive function in mid- to late life may be confounded by other factors not included in our models (e.g., *hukou* origin and change, employment history, lifestyles, and social support).

Like most previous studies examining the role of early-life environment in late-life cognitive functioning, our study has several limitations. First, our measures of childhood conditions, except for knee height, are based on retrospective self-reports; therefore, there is a potential problem of recall bias, which may result in underestimation of the association between childhood conditions and cognition (Horvat et al., 2014) Second, our measure of nutritional status in childhood (knee height), although valid, was not perfect. Previous research suggests that knee height is not only influenced by food intake but also by infections and the ensuing inflammation (Crimmins & Finch, 2006). Therefore, the association between knee height and cognition function in our study may be due to both nutritional status and inflammation in childhood. Third, due to sample size constraints, we were not able to examine the association between childhood conditions and late-life cognition

for the 1959 to 1961 cohorts that grew up in the Great Leap Forward Famine. This cohort's experience offers a unique opportunity to examine how in utero, infancy, and childhood exposure to severe famine may affect cognition in later life. Fourth, we only examined one important domain of cognitive function (episodic memory). Future research should examine whether other cognitive domains (e.g., processing speed, executive function) are also influenced by childhood factors. Finally, we used cross-sectional data, and all associations are correlations. Future research using longitudinal data and more rigorous methodology is needed to disentangle the complex pathways between childhood conditions and late-life cognition.

Despite these limitations, our study has several strengths, including the use of nationally representative data from China; the inclusion of important childhood characteristics such as urban residence, parental education, health, and nutrition; and the examination of gender and cohort variations in the association between childhood factors and memory. Our study adds to a growing body of literature indicating that there is a long-term impact of childhood environment on cognitive function in mid- to late life. Furthermore, our results suggest that the association between childhood factors and cognitive function may vary by gender and cohort. Finally, we found that adulthood SES, education in particular, partially accounts for the association between childhood factors and cognitive function for both middle-aged and older men and women in China. Taken together, our results suggest that reducing rural–urban divide in access to education and other socioeconomic resources and increasing investments in children's nutrition and education will pay dividends many decades later in terms of cognitive health.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

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