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Childhood nutritional deprivation and cognitive impairment among older Chinese people

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ABSTRACT

Late-life cognitive impairment may have its origins in childhood. Here, we examine the associations between markers of childhood nutritional deprivation and cognitive impairment in older adults. We made use of the 2002 and 2005 waves of the Chinese Longitudinal Healthy Longevity Survey to examine these associations for persons aged 65–105 ($N = 15{,}444$). Anthropometric measures (arm length, knee height) and self-reported hunger were used to measure early-life nutritional deficiencies. Cognitive impairment was measured using the Chinese version of the Mini Mental State Examination. Results from multivariate logistic regression models show that both anthropometric measures and self-report markers of early-life nutritional status were significantly associated with the odds of cognitive impairment at baseline for both men and women after controlling for age and ethnicity. Adjustments for childhood and adulthood socioeconomic status, adulthood health, and lifestyle habits had little effect on these associations except for the effect of hunger among men. Results from multinomial logistic regression models show that during the three-year follow-up period, arm length was significantly associated with the onset of cognitive impairment after controlling for various confounders in men, but not in women. Our findings suggest that early-life nutritional deprivation may contribute to cognitive impairment among older Chinese adults.

Background

Undernutrition in infancy and childhood has clear negative consequences for children's cognitive development. However, it is less clear whether this adverse effect persists into adolescence, adulthood, and old age (Case & Paxson, 2008; Mendez & Adair, 1999) as an individual's cognitive functioning continues to develop over the life span. Recent studies in the U.S., England, Israel, and Korea demonstrate the plausibility of this association, reporting that limb length (arm span, knee height, leg length, and height), a marker of early childhood growth and development, is inversely associated with cognitive impairment, cognitive decline, and Alzheimer's disease late in life (Abbott et al., 1998; Beeri et al., 2005; Huang et al., 2008; Jeong et al., 2005; Petot et al., 2007). However, relatively little is known about whether this association exists in developing countries, where early-life conditions and the prevalences of hunger and stunting are much worse than in developed countries. In 2009, two regional studies in southern China found that daily milk drinking in childhood and greater height were positively associated with mid- to late-life cognitive function (Heys et al., 2009; Zhang et al., 2009). This study contributes to this line of research by investigating the associations between markers of early-life nutritional deprivation and cognitive impairment among a nationwide random sample of adults aged 65 and over in China at baseline and during a three-year follow-up. The older Chinese population has experienced extraordinary levels of undernutrition on a broad scale compared with most developed countries in the 20th century.

Until recently, most research has focused on the impact of early-life undernutrition on physical health and mortality, with much less attention devoted to its long-term, cumulative negative effects on cognitive functioning. This issue is especially important for developing countries, where a large proportion of the current cohort of older adults has experienced childhood poverty, hunger, and exposure to infectious diseases.

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Childhood nutritional deprivation and cognitive function in late-life

Increasingly, the life course approach has been used to evaluate the determinants of cognitive functioning in late-life. Cumulative disadvantage theory posits that insults throughout the life course (e.g., childhood poverty, illness and unhealthy behavior, physically demanding jobs) can accumulate and negatively affect people's health in late-life. The theory also suggests that early risk factors can be compounded across the life course by setting people onto different life trajectories such that earlier disadvantages lead to later disadvantages, which results in increasing health inequalities in later life (Crystal & Shea, 1990; Haas, 2008; O'Rand & Hamil-Luker, 2005).

Although prior research has shown that both early-life and late-life conditions are associated with older adults' cognitive functioning, the evidence for the pathways through which early-life factors affect later life cognition is less clear. The critical period hypothesis posits that undernutrition in early-life impairs brain development and leads to less efficient brain function because of "less myelin, less branching of dendrites, and less developed connectivity patterns" (Moceri, Kukull, Emanuel, van Belle, & Larson, 2000, p. 415). The negative effects of the impaired brain development may be small until they are aggravated by the aging process (Moceri et al., 2000). A recent study found that lower childhood cognitive ability was associated with the development of late-onset dementia, suggesting that cognitive deficits in early-life may put individuals at higher risk of cognitive impairment in late-life (Deary, Whiteman, Starr, Whalley, & Fox, 2004). Thus, nutritional deprivation during developmentally important periods *(in utero* and early childhood) may have *long-term* negative effects on cognitive function. Due to data limitations, few researchers have been able to develop a strong test of this idea because of the lack of data on the childhood cognitive functioning of their older respondents. Two studies took advantage of longitudinal data to investigate whether early-life nutritional deprivation was associated with late-life cognitive decline and reported conflicting findings. Mak, Kim, and Stewart (2006) found, among a sample of 290 African-Caribbean residents of south London, that shorter leg length was associated with cognitive impairment at baseline but not associated with cognitive decline over a three-year follow-up. In contrast, using a national sample with an average of 5.4 years of follow-up in the U.S., Huang et al. (2008) reported that a longer arm span was associated with lower dementia incidence for both men and women.

The pathway model is an alternative hypothesis that emphasizes mechanisms wherein nutritional disadvantages in early-life *indirectly* influence late-life cognition via social conditions and health problems related to cognitive functioning. For example, a large body of research has reported an inverse relationship between education and late-life cognition as measured by cognitive tests, cognitive decline, or dementia (Cagney & Lauderdale, 2002; Zhang et al., 1990). Researchers have argued that education in early-life promotes brain growth in the formative years and enables the brain network to operate more efficiently, thus providing protection against cognitive decline in later life (Fritsch et al., 2007; Kaplan et al., 2001). Malnourished children might lack the energy and motor skills essential to thrive in school and thus complete fewer years of schooling, which in turn affects late-life cognition (Mendez & Adair, 1999). In addition, higher levels of education often lead to occupations that involve cognitive challenges and practice, which could further enhance – or maintain – cognitive functioning in adulthood (Andel, Kareholt, Parker, Thorslund, & Gatz, 2007; Schooler, 1987). Finally, the research linking early-life nutritional deficiencies with cardiovascular and metabolic conditions points to possible physical disease pathways. Cardiovascular and metabolic conditions are both associated with cognitive impairment, suggesting that early-life nutrition may set in motion a cascade of physical health problems resulting in cognitive impairment (National Research Council, 2000). Most recently, Case and Paxson (2008) found some support for the pathway model. Especially noteworthy in their results was the reduction in the association between height and five out of six domains of cognitive functioning when education was controlled for. Their results provided substantially less evidence for occupation and physical health conditions as mechanisms linking early-life nutritional status and cognitive function. In reality, the mechanisms suggested in the critical period and pathway hypothesis may operate together in complex ways to determine cognitive functioning in later life.

The current study

Our focus on China provides a more global perspective on the association between early-life nutritional deprivation and late-life cognitive functioning. Many of China's surviving older individuals suffered from hunger and devastating wars in their childhood (Zeng, Gu, & Land, 2007). Before 1949, for example, the life expectancy at birth in China was 35 years (China Internet Information Center, 2008). We take advantage of a large longitudinal population-based survey conducted in China that includes two markers of early-life nutritional status: the anthropometric measures of arm length and knee height and self-reported experience with hunger in childhood. Prior population-level studies of the effects of nutritional deprivation have often relied solely on adult anthropometry (Abbott et al., 1998; Huang et al., 2008), except for a recent study by Zhang et al. (2009). The advantage of multiple indicators is that the anthropometric measures may best capture nutritional deprivation in the early stages of growth because differences in knee height seem to be largely determined in the first two years of life (Huang et al., 2008), while self-reported hunger most likely captures nutritional deprivation and catch-up growth later in childhood, when the person has become able to remember those experiences (Adair, 1999). In the study, we hypothesized, first, that childhood nutritional deprivation would be associated with increased odds of cognitive impairment at baseline and onset over the three-year follow-up period. Second, the effect of childhood nutritional deprivation on cognitive impairment would be reduced after controlling for adult SES and other adult factors.

Methods

Sample

The Chinese Longitudinal Healthy Longevity Survey (CLHLS) began in 1998 and was distributed in one randomly selected half of the counties and cities in 22 of China's 31 provinces. The surveyed areas covered about 85% of the total Chinese population. Local aging committees provided lists of centenarians in randomly selected counties/cities, including persons residing in institutions. For each centenarian with a pre-designated random code, one nearby octogenarian and one nearby nonagenarian of pre-designated age and sex were interviewed. The term 'nearby' mainly indicated the same village or street, if applicable, or the same town, county, or city. The aim of this special sampling technique was to produce comparable numbers of randomly selected male and female octogenarians and nonagenarians at each age from 80 to 99. We made use of the third and fourth waves, collected in 2002 and 2005, respectively, because the sample was extended to include the elderly aged 65 to 79 as a comparison with the oldest old beginning