Archives of Gerontology and Geriatrics 81 (2019) 31–38

Contents lists available at ScienceDirect

Archives of Gerontology and Geriatrics

journal homepage: www.elsevier.com/locate/archger

Gender differences in the association between migration and cognitive function among older adults in China and India

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ARTICLE INFO

Keywords:
Aging
Cognition
Gender
Health disparities
China
India

ABSTRACT

Objective: This study aims to examine gender differences in the association between migration and cognitive function among adults in China and India.

Methods: Data from the World Health Organization Study on global AGEing and adult health (SAGE) study were used that included adults aged 50 + from China (N = 12,937) and India (N = 6244). Migration status included: urban residents, rural residents, urban-to-urban, rural-to-urban, rural-to-rural, and urban-to-rural migrants. Cognitive function was assessed by immediate and delayed recall tests, digit span tests, and verbal fluency test. Ordinary least square regression models were used to adjust for sociodemographic characteristics, psychosocial factors, health behaviors, and physical health status.

Results: Controlling for multiple covariates, significant differences in cognitive function were found between men and women, and across migration groups. A consistent female disadvantage was found in China and India for cognitive function. Women who were rural residents or rural-to-rural migrants had the poorest cognitive function in both the Chinese and the Indian samples. Among males in China, rural residents had poorer cognitive function than urban residents, while urban-to-urban migrants had highest cognition scores; however, for male counterparts in India, rural-to-rural migrants had the poorest cognitive function.

Conclusions: The results suggest that the association between migration and cognitive function differs by gender and country. In our study populations, major sociodemographic characteristics play a key role in accounting for the differences in cognitive function.

1. Introduction

Over 300 million adults aged 60 years or over are currently living in China or India, accounting for about one third of the world's aging population; and this number is projected to continue increasing in the next 15 years (United Nations, Department of Economic & Social Affairs, 2015). As more people are entering into older ages, more people are at a higher risk of experiencing cognitive impairment. According to recent estimates, there are over 9.5 million persons with dementia in China and another 4.1 million in India (Prince et al., 2015). The burden of older adults with some levels of cognitive impairment continues to put enormous strains on healthcare systems.

In addition to the population aging and the coming dementia epidemic in China and India, both countries have been experiencing rapid sociodemographic changes (Bosworth & Collins, 2008). With urbanization and economic development, the internal migrants in China and India have been increasing dramatically in the past few decades (Bhagat, 2015, 2016; Chan & Zhang, 2009; International Organization for Migration, 2015). Currently, internal migrants account for one sixth of the total population in China and one third in India; and these populations are projected to grow in the next 20 years (Bhagat, 2016; Zheng & Yang, 2016). Although China and India both have had a recent

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https://doi.org/10.1016/j.archger.2018.11.011
Received 7 August 2018; Received in revised form 12 November 2018; Accepted 20 November 2018
Available online 22 November 2018
0167-4943/

increase in internal migrant populations, India differs from China in the patterns of migration for men and women (Jones, 2016). In India, rural to urban migration is the most common stream in male migrants, whereas rural to rural migration is the dominant form of migration in female migrants (Bhagat, 2015). In China, the major internal migration flows are from rural to urban areas and from urban to urban areas, with a slightly higher proportion of men in these two categories of migration (Zheng & Yang, 2016).

Increasing evidence has suggested that migration may have a profound impact on later-life cognitive function through migration-related changes in socioeconomic status, psychosocial factors, and health behaviors (Graves et al., 1999; Hill, Angel, Balistreri, & Herrera, 2012; Xu, Dupre, Gu, & Wu, 2017; Xu, Zhang, & Wu, 2017; Zeki Al Hazzouri et al., 2011). Recent studies in China and India have found that different migration patterns could be associated with cognitive function in various ways (Xu, Dupre et al., 2017; Xu, Zhang et al., 2017; Xu, Dupre, Østbye, Vorderstrasse, & Wu, 2018; Xu, Ostbye, Vorderstrasse, Dupre, & Wu, 2018). For example, in China, urban residents and urban-to-urban migrants had the highest level of cognitive function, whereas rural residents and rural-to-rural migrants had the poorest cognitive function (Xu, Dupre et al., 2018). Similar associations were reported in another study conducted in India (Xu, Dupre et al., 2018). In addition to the associations between migration and cognition, a number of recent studies in China and India have found that women have significantly poorer cognitive function in later-life than their male counterparts (Lee, Shih, Feeney, & Langa, 2014; Lei, Hu, McArdle, Smith, & Zhao, 2012; Oksuzyan, Singh, Christensen, & Jasilionis, 2017; Zhang, 2006). However, given the gender differences in migration patterns and later-life cognitive function, existing research regarding gender differences in the relationship between migration and cognition is scarce and primarily focuses on immigrant populations. A study of Mexican immigrants found that only men who migrated in middle-life have a slower rate of cognitive decline (Hill et al., 2012).

Furthermore, No study to date has compared these associations across nations. The major socioeconomic and demographic changes occurring in China and India provide unique contexts to conduct comparative studies on the association between migration and cognitive function in the world's two most populous nations.

The purpose of this study is to provide the first comparative investigation of the gender differences in the association between migration and cognitive function among the adult population in China and India. We used data from a nationally representative sample of older adults from the WHO Study on global AGEing and adult health (SAGE). We first examined how cognitive function differed by migration status, gender, and country. Next, we examined the interaction effects among migration, gender, and country on cognitive function. In addition, several extensive scientific reviews have summarized the latest evidence on risk factors related to cognitive impairment and dementia (Livingston et al., 2017; National Academies of Sciences Engineering & Medicine, 2017). Therefore, we also examined whether these differences can be explained by major sociodemographic, psychosocial, behavioral, and physiological risk factors.

2. Methods

2.1. Data source and sample

We used data collected in the SAGE of adults aged 50 or older. SAGE Wave 1: 2007–2010 included nationally representative samples of 13,175 respondents from China and another 7150 from India. The overall response rate in individual surveys was over 85%.(Kowal et al., 2012) Detailed information about the SAGE background, sampling, and questionnaires is documented elsewhere (Kowal et al., 2012). We analyzed the data from SAGE Wave 1 that included a total of 18,654 adults aged 50 or older with no missing information on migration status and cognitive function (92%).

2.2. Study variables

Following prior studies' approach, we generated a Cognitive Composition Score (CCS) to measure respondents' cognitive function (Oksuzyan et al., 2017). The CCS is a summary of five individual cognitive tests: digital span tests (forward and backward), verbal fluency test, and immediate and delayed recall tests. Results from principal component factor analyses supported a one-component structure across the five tests based on their eigenvalues (Eigenvalues for component 1: 2.62, for component 2: 0.89). The internal consistency test also suggested adequate internal consistency across the five tests (Cronbach's alpha = 0.77). The total score of CCS ranged from 0 to 47, with higher scores indicating better cognitive function.

In the SAGE study, respondents' migration status was assessed by the following three questions: 1) current place of residence ("rural" or "urban"), 2) whether the participant has always lived in this place ("yes" or "no"), and 3) where the respondent has lived before ("in same community," "in another city in this region," "in another rural area in this region," "in another city outside this region but in this country," "in another rural area outside this region but in this country," and "outside the country"). Using a similar approach as suggested in previous studies, we categorized respondents' migration status into six groups (Oyebode et al., 2015; Xu, Dupre et al., 2018). We defined urban residents as those living in the same urban community all their life. Similarly, rural residents were respondents who had been living in the same rural area all their life. We defined rural-to-urban migrants as respondents who were currently living in an urban area but reported living in a rural area before moving to their current locations. Urban-to-urban migrants were those who had relocated from other urban areas to their current urban locations. We used a similar approach to define rural-to-rural migrants. Finally, we characterized urban-to-rural migrants as respondents who were currently living in rural areas but reported living in urban settings previously.

We included multiple covariates including demographics, socioeconomic status (SES), psychosocial and behavioral factors, and physical health status in the analyses. Demographic background included age (as a continuous variable) and gender. SES included measures of education (no education, primary or less, or secondary or above), income quintiles, and parental education (two binary indicators to assess whether respondents' mother or father received any formal education).

Psychosocial and behavioral factors included marital status (currently married or not), household size (#), social cohesion, family/community support (yes or no), having depressive symptoms, current smoking (yes or no), current alcohol consumption (yes or no), and adequate physical activity (yes or no). We generated a dichotomous variable to assess whether respondents reported any depressive symptoms based on DSM-IV (American Psychiatric Association, 2000). SAGE included 9 questions related to social cohesion that captured the frequency of different social activities (e.g., having friends over, working with others in the neighborhood). We created a social cohesion summary scale based on the 9 questions (Kowal, Ng, & Chatterji, 2010). The total score ranged from 9 to 45, with higher scores indicating higher levels of social cohesion. We considered respondents as having family or community support if they reported having received any financial or in-kind support from family members or community. For physical activity, we defined an adequate amount as at least 150 min of moderate-intensity or at least 75 min of vigorous-intensity aerobic physical activity per week based on the WHO recommendation (World Health Organization, 2010).

Physical health status included body mass index (BMI), chronic diseases, and physical function. We categorized BMI into four groups according to the WHO classification for Asian populations: underweight (< 18.5 kg/m2), normal (18.5–22.9 kg/m2), overweight (23–27.4 kg/m2), and obese (≥ 27.5 kg/m2). (Barba et al., 2004) We used 4 dichotomous indicators of chronic diseases in the analyses: hypertension (yes or no), diabetes (yes or no), angina (yes or no), and stroke (yes or

no). Finally, we created a binary indicator to capture respondents' physical function using the 12-item version of World Health Organization Disability Assessment Schedule (WHODAS) 2.0 (coded as 1 if they needed help with 1 or more items) (Arokiasamy et al., 2015; Xu, Dupre et al., 2018).

2.3. Statistical analysis

We used weighted descriptive statistics to characterize the study sample separately for men and women and by country. We then assessed whether respondents' cognitive function differed by gender and country and whether there was an interaction effect between gender and country (Supplementary Table 1). The Indian sample exhibited poorer cognitive function than the Chinese; women showed worse cognitive performance than men in both countries. In addition, we found that women in India had poorer cognitive function than women in China. To account for significant differences by gender and country, we performed stratified analyses using unweighted ordinary least square regression models to examine the association between migration and cognitive function. We then assessed how demographics, SES, psychosocial and behavioral factors, and physical health status contributed to the associations. We used the Bayesian information criterion (BIC) to evaluate model fit. To reduce potential bias in the estimates due to missing cases (< 15% across all covariates), we applied multiple imputation methods in the analyses. We found similar estimates using alternative strategies (e.g., listwise deletion) to account for missing data. The results of analyses using listwise deletion are not included. We included sampling weights in the descriptive analyses to account for sampling design and the over/under-representation of some population groups. We did not apply weights in all multivariate analyses because unbiased estimates can be obtained by including variables (e.g. age, sex, and rural-urban residence) related to sampling criteria (Winship & Radbill, 1994). All of the analyses were performed using Stata SE 15.1.

3. Results

Characteristics of the study respondents are presented for men and women by country in Table 1. In both countries, women were generally more likely to be migrants and had fewer socioeconomic resources —with the exception of income in Chinese women—than their male counterparts. Compared with men, women in both countries were also less likely to be married, smoke, or drink, but more likely to live in smaller households, have depressive symptoms, or have lower levels of social cohesion. Women in China had more chronic conditions and a higher BMI than their male counterparts; whereas Indian women tended to have a lower BMI and fewer chronic conditions except for hypertension. In both countries, women reported a higher level of physical disability than men. The proportions of the Indian population who had no education, reported having depressive symptoms, had underweight BMI, and experienced physical disability were higher than those of their Chinese counterparts. The CCS for cognitive function was lower among women than among their male counterparts, but the female disadvantage was smaller in China than in India (male-female difference: 2.2 for China vs 4.0 for India). Supplementary Table 2 shows the descriptive statistics of each cognitive test by migration status and country among men and women.

Fig. 1 illustrates cognitive function by migration status in men and women from both countries (plotted from estimates in Tables 2 and 3). A consistent female disadvantage was found in China and India for cognitive function. In addition, the Indian population in general showed poorer cognitive function than the Chinese population in both men and women.

The age adjusted models conducted among female participants showed that rural residents, rural-to-rural migrants, and urban-to rural migrants had significantly poorer cognitive function than urban residents (Table 2). Indian women who were rural-to-urban migrants also demonstrated poorer cognitive function than urban residents. When adjusting for all study covariates, the differences in cognition were attenuated; still, rural residents and rural-to-rural migrants exhibited significantly poorer cognitive function than urban residents in both countries.

In men (Table 3), we also found that adjusting for age, rural residents and rural-to-rural migrants had significantly poorer cognitive function than urban residents in both countries. However, after accounting for all covariates, the differences in cognitive function remained only between rural-to-rural migrants and urban residents among Indian men, and between rural residents and urban residents among Chinese men. Additionally, we found that among males in China, urban-to-rural migrants had poorer cognitive function than urban residents, while urban-to-urban migrants exhibited the highest cognition scores. The advantage in cognitive function among Chinese men who were urban-to-urban migrants remained largely unchanged after accounting for numerous covariates.

Based on BIC values, overall model fit improved when we accounted for a variety of covariates. We also performed sensitivity analyses using cognitive function z-scores as the outcome variable. We derived z-scores from each test and then calculated the average of the five cognitive tests to create a global cognitive score (See Supplementary Fig. 1). The results using z-scores were similar to those we presented in this study.

4. Discussion

Our study is the first investigation of the gender differences in the association between migration and cognitive function among the adult populations in China and India. We found that cognitive function was significantly different by migration status in men and women. Some of the differences also varied by country and persisted after adjustment for multiple socioeconomic, psychosocial, behavioral, and health factors.

In line with previous research in China and India (Lee et al., 2014; Lei et al., 2012; Oksuzyan et al., 2017; Xu, Dupre et al., 2018; Zhang, 2006), we found that women in both countries who resided in rural areas had significantly poorer cognitive function than urban residents controlling for all study covariates. In our sample, we found a higher proportion of women with no education in the rural resident group than in the urban resident group in China (48.8% vs. 18.0%) and in India (72.9% vs. 43.8%). This cognitive disadvantage that we observed among female rural residents may be explained by the negative impacts of living in rural settings, such as limited access to education, workforce participation, and health care (Lee et al., 2014; Zhang, Gu, & Hayward, 2008). We also found that women who migrated within rural areas exhibited the poorest cognitive function both in China and India. The explanations for these findings may be twofold. First, similar to rural residents, women who moved within rural areas are likely to be influenced by the rural living environment that could have negative impacts on cognitive function (Lee et al., 2014; Zhang et al., 2008). In addition to that, marriage is the dominant reason for women to move from one rural area to another in both countries (Bhattacharya, 2000; Chan, 2012). We speculate that women who migrated within rural areas for marriage may experience separation from their biological families and friends that can lead to reduced social support. Therefore, they may have fewer opportunities to engage in social activities and expand their social connections outside of the household. Prior research has shown that social support and social engagement are associated with better cognitive function (Krueger et al., 2009; Yeh & Liu, 2003). Together, we suspect that a combination of factors including socioeconomic disadvantages, a lack of social support and social engagement are detrimental to the cognitive health of older women who moved within rural areas. We also found that among female populations in both countries, no significant difference exists in cognitive function between urban residents and urban-to-urban migrants. It is possible that family-related migration is a major reason for women who migrated from one urban

Table 1
Characteristics of Study Sample in SAGE China and India, 2007–2010.

	China (n = 12,410)			India (n = 6244)		
	Men (n = 5812)	Women (n = 6598)	*p* value	Men (n = 3180)	Women (n = 3064)	*p* value
Migration Status, %			< .001			< .001
Urban residents	31.8	37.8		23.9	15.2	
Rural residents	55.9	34.7		64.2	24.8	
Urban-urban migrants	7.0	8.2		2.4	7.2	
Rural-urban migrants	2.8	4.3		1.2	7.1	
Rural-rural migrants	1.9	14.0		4.0	42.1	
Urban-rural migrants	0.5	1.0		1.4	3.6	
CCS, mean (SD)	45.3 (11.3)	43.1 (11.4)	< .001	39.2 (8.7)	35.2 (8.7)	< .001
Age, mean (SD)	62.1 (8.4)	62.8 (9.3)	< .001	61.3 (8.5)	61.1 (9.0)	.524
Education level, %			< .001			< .001
No education	12.6	32.6		29.7	72.3	
Primary or less	44.8	37.9		30.7	19.0	
Secondary and above	42.6	29.5		39.6	8.8	
Income quintile, %			.383			.016
Lowest	16.4	16.7		16.9	19.1	
Second	18.9	18.0		18.6	19.3	
Middle	20.9	20.5		18.7	19.4	
Fourth	23.8	23.4		21.5	18.3	
Highest	20.0	21.4		24.3	24.0	
Father received any education, %	31.5	30.1	.159	35.8	32.0	.029
Mother received any education, %	12.4	12.2	.722	10.4	9.3	.276
Married, %	90.5	80.1	< .001	91.3	62.3	< .001
Received family support, %	35.1	36.6	.119	25.0	27.6	.015
Received community support, %	2.5	2.3	.507	6.3	7.0	.244
Household size, mean (SD)	2.7 (1.2)	2.7 (1.4)	.033	7.0 (4.4)	6.7 (4.0)	.011
Socio cohesion Index, mean (SD)	15.4 (3.5)	15.1 (3.7)	< .001	19.6 (5.1)	16.0 (4.2)	< .001
Having depressive symptoms, %	14.2	17.1	< .001	37.2	42.9	.001
Current smoker, %	56.5	3.7	< .001	67.1	32.0	< .001
Current drinker, %	57.1	11.7	< .001	27.8	2.2	< .001
Adequate physical activities, %	75.3	72.5	.001	80.9	79.1	.290
BMI, %			< .001			.001
Underweight	4.3	4.3		39.3	36.9	
Normal	41.3	33.8		42.1	36.8	
Overweight	42.2	42.9		13.7	16.7	
Obese	12.1	18.9		4.8	9.6	
Stroke, %	3.5	2.5	.012	2.0	1.6	.398
Heart disease, %	6.0	9.8	< .001	6.8	4.2	.001
Hypertension, %	61.3	62.5	.195	26.9	29.6	.079
Diabetes, %	5.5	7.4	.015	8.4	5.7	.001
Having physical disabilities, %	10.3	15.2	< .001	41.5	61.7	< .001

Note: Values are expressed as percentages unless otherwise indicated. CCS indicates cognitive composition score; SD, standard deviation.

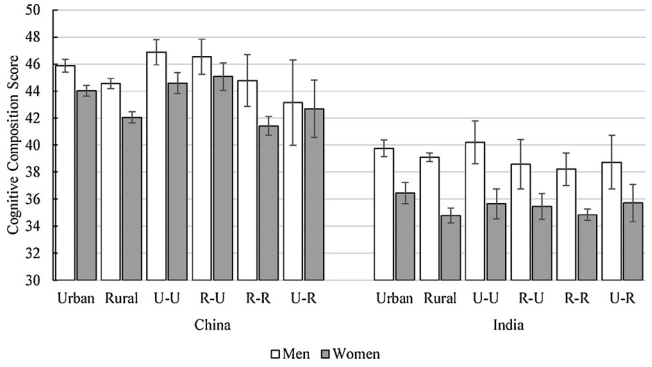

Fig. 1. Comparison of Cognitive Function by Migration Status and Gender in China and India.
Note: results from fully adjusted models: adjusted for age, education, household income, parental education, marital status, family/community support, household size, social cohesion, depression, smoking history, alcohol consumption, exercise, body mass index, stroke, heart disease, hypertension, diabetes, and functional status.

area to another urban area (Mahapatro, 2012). Therefore, women who were urban-to-urban migrants may not experience the upward social mobility that is often considered a protective factor for cognitive function in later life.

Our results for men showed differences in the association between migration and cognitive function between China and India. Among male populations in China, we found that rural residents had poorer cognitive function than their urban counterparts, which may be partially due to the negative impact of living in rural settings as previously discussed (Zhang, 2006; Zhang et al., 2008). We also found that Chinese men who were urban-to-urban migrants exhibited the highest level of cognitive function. It is likely that some proportion of these respondents migrated from small townships to metropolitan areas or moving within metropolitan areas for college education and employment opportunities after the economic reform (Chan, 2012; Gu, Feng, Sautter, & Qiu, 2017). Therefore, these urban-to-urban migrants may benefit from improvements in their SES and related resources that can have a long-lasting positive impact on cognitive function. In addition to the benefits from upward social mobility, migrating from one urban area to another may reflect a self-selection process: individuals who migrated are likely to be healthier and have better cognitive function (Tong & Piotrowski, 2012). A similar pattern was found among Indian men who were urban-to-urban migrants, although the results were not significant. One possible explanation is the small proportion of urban-to-urban migrants among the Indian male population in the SAGE data. Still, additional studies are needed to further test these explanations. In Indian men, we found that after adjusting for all study covariates, rural-to-rural

Table 2
Parameter Estimates for Cognitive Function by Migration Status Among Women in China and India.

	China				India			
	Model1		Model 2		Model 1		Model 2	
Migration Status (Ref: Urban residents)								
Rural residents	−6.54***	(0.29)	−1.96***	(0.32)	−5.45***	(0.51)	−1.66***	(0.49)
Urban-urban migrants	0.57	(0.47)	0.57	(0.43)	0.40	(0.72)	−0.80	(0.66)
Rural-urban migrants	−0.56	(0.60)	1.06	(0.55)	−2.36***	(0.67)	−0.99	(0.62)
Rural-rural migrants	−6.80***	(0.42)	−2.60***	(0.43)	−5.19***	(0.47)	−1.61***	(0.46)
Urban-rural migrants	−4.89***	(1.20)	−1.33	(1.11)	−2.29**	(0.87)	−0.75	(0.80)
Age	−0.49***	(0.01)	−0.25***	(0.02)	−0.22***	(0.02)	−0.09***	(0.02)
Education (Ref: No education)								
Primary or less			3.28***	(0.30)			2.71***	(0.39)
Secondary and above			6.46***	(0.38)			7.11***	(0.60)
Income quintile (Ref: Lowest)								
Second			1.32***	(0.37)			1.20*	(0.47)
Middle			2.21***	(0.37)			1.75***	(0.48)
Fourth			4.09***	(0.39)			2.66***	(0.49)
Highest			4.96***	(0.41)			3.48***	(0.52)
Father received any education			1.30***	(0.31)			0.70	(0.40)
Mother received any education			1.69***	(0.41)			0.78	(0.55)
Married			1.18***	(0.31)			1.15***	(0.31)
Received family support			−0.28	(0.27)			0.31	(0.30)
Received community support			0.65	(0.83)			0.30	(0.48)
Household size			−0.63***	(0.09)			−0.10*	(0.04)
Socio cohesion Index			0.32***	(0.03)			0.16***	(0.03)
Having depressive symptoms			−0.76*	(0.31)			0.01	(0.29)
Current smoker			−0.65	(0.61)			−0.85**	(0.30)
Current drinker			0.54	(0.37)			−2.93***	(0.83)
Adequate physical activities			0.20	(0.26)			2.25***	(0.36)
BMI (Ref: Normal)								
Underweight			0.08	(0.55)			−0.68*	(0.32)
Overweight			−0.01	(0.26)			0.82	(0.43)
Obese			−0.67	(0.46)			0.42	(0.65)
Stroke			−1.25	(0.68)			−0.15	(1.08)
Heart disease			−1.57***	(0.39)			−0.46	(0.68)
Hypertension			−0.47	(0.24)			−0.84**	(0.30)
Diabetes			−0.34	(0.46)			1.07	(0.56)
Having physical disabilities			−2.40***	(0.37)			−0.86**	(0.31)
Constant	76.97***	(0.86)	50.25***	(1.36)	52.39***	(1.12)	34.90***	(1.48)
Goodness-of-Fit								
BIC value	90197.4		80295.71		44373.76		38847.37	
Observations	6598		6598		3064		3064	

Abbreviations: BIC, Bayesian information criterion.
Note: Unstandardized coefficients (standard errors) are reported.
Model 1 adjust for age. Model 2 adjusts for age, education, household income, parental education, marital status, family/community support, household size, depression, smoking history, alcohol consumption, exercise, body mass index, stroke, heart disease, hypertension, diabetes, and functional status.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

migrants still had significantly poorer cognitive function than urban residents. Prior studies have suggested that male rural-to-rural migrants in India are likely to be laborers from poorer regions who travel for agricultural activities such as rice cultivation (Bhattacharya, 2000; Srivastava & Bhattacharyya, 2003). In our Indian sample, the male rural-to-rural migrants exhibited the lowest socioeconomic standing among the 6 groups. Therefore, we speculate that the poor cognitive function we observed in the male rural-to-rural migrant group might be partially explained by their socioeconomic disadvantages. We also found that rural-to-rural migrants in the Chinese male population had poorer cognitive function than urban residents after adjusting for age. However, the differences in cognition became non-significant when we accounted for socioeconomic factors in the model, which suggested that this difference was partially explained by their SES. It is not clear from our data and the current literature why Chinese men migrate within rural areas. We speculate that some these rural-to-rural male migrants may move from villages to suburban areas to work in small business sectors. Because some of these suburban areas are still considered as rural areas due to the current household registration system in China, these migrants can be categorized as rural-to-rural migrants. Therefore, we encourage future research to further examine the reason(s) for migration in this group and how they may be associated with cognitive function.

We found no difference in cognitive function between rural-to-urban migrants and urban residents in men and women from either country after accounting for study covariates. One possible explanation is that men and women in China and India tend to migrate from rural areas into cities early in their adulthood for education and employment purposes (Bhagat, 2016; Chan & Zhang, 2009; Zheng & Yang, 2016). Therefore, the improved SES associated with rural-to-urban migration and the current urban living environment may help rural-to-urban migrants buffer the negative impact of their prior exposures to rural settings and loss of social network. (Zhang et al., 2008) We also found that in age-adjusted models, urban-to-rural migrants had poorer cognitive function than urban residents across all groups (except Indian men). Although little is known about reasons for migrating from an urban area to a rural setting, results from our exploratory analyses showed that the differences in cognitive function between urban-to-rural migrants and urban residents were reduced after accounting for SES factors. Therefore, we speculate that the cognitive differences we observed in Model 1 may be partially related to fewer socioeconomic recourses in rural settings. However, the unbalanced number of

Table 3
Parameter Estimates for Cognitive Function by Migration Status Among Men in China and India.

	China				India			
	Model1		Model 2		Model 1		Model 2	
Migration Status (Ref: Urban residents)								
Rural residents	−5.04***	(0.30)	−1.31***	(0.34)	−3.45***	(0.38)	−0.67	(0.37)
Urban-urban migrants	1.74**	(0.54)	0.99*	(0.50)	1.67	(0.94)	0.44	(0.85)
Rural-urban migrants	0.28	(0.75)	0.67	(0.69)	−0.98	(1.10)	−1.18	(0.98)
Rural-rural migrants	−5.32***	(1.08)	−1.11	(1.01)	−5.28***	(0.77)	−1.54*	(0.70)
Urban-rural migrants	−5.72**	(1.76)	−2.74	(1.64)	−2.24	(1.18)	−1.03	(1.06)
Age	−0.44***	(0.01)	−0.24***	(0.02)	−0.25***	(0.02)	−0.12***	(0.02)
Education (Ref: No education)								
Primary or less			3.86***	(0.41)			2.19***	(0.35)
Secondary and above			6.66***	(0.46)			5.36***	(0.40)
Income quintile (Ref: Lowest)								
Second			0.75	(0.40)			0.70	(0.45)
Middle			1.56***	(0.41)			1.67***	(0.47)
Fourth			4.25***	(0.42)			2.14***	(0.47)
Highest			5.37***	(0.46)			4.04***	(0.51)
Father received any education			1.83***	(0.34)			0.15	(0.33)
Mother received any education			0.91*	(0.44)			1.05*	(0.48)
Married			1.43***	(0.42)			1.18**	(0.41)
Received family support			−0.00	(0.30)			0.26	(0.30)
Received community support			1.36	(0.88)			−0.22	(0.48)
Household size			−0.59***	(0.10)			0.01	(0.04)
Socio cohesion Index			0.36***	(0.04)			0.17***	(0.03)
Having depressive symptoms			−1.27***	(0.38)			0.14	(0.29)
Current smoker			−0.17	(0.27)			0.55	(0.29)
Current drinker			0.47	(0.26)			−0.61*	(0.30)
Adequate physical activities			−0.03	(0.29)			2.11***	(0.35)
BMI (Ref: Normal)								
Underweight			0.41	(0.62)			−0.95**	(0.30)
Overweight			1.09***	(0.31)			1.19*	(0.48)
Obese			−0.34	(0.72)			0.13	(0.97)
Stroke			−2.31***	(0.65)			−0.59	(0.83)
Heart disease			−1.08*	(0.50)			0.37	(0.58)
Hypertension			−0.38	(0.27)			−0.49	(0.29)
Diabetes			0.22	(0.54)			−0.20	(0.50)
Having physical disabilities			−3.41***	(0.46)			−1.34***	(0.30)
Constant	75.37***	(0.97)	48.66***	(1.50)	57.32***	(1.07)	37.10***	(1.44)
Goodness-of-Fit								
BIC value	82165.93		72853.69		35577.39		31969.63	
Observations	5812		5812		3180		3180	

Abbreviations: BIC, Bayesian information criterion.
Note: Unstandardized coefficients (standard errors) are reported.
Model 1 adjust for age. Model 2 adjusts for age, education, household income, parental education, marital status, family/community support, household size, depression, smoking history, alcohol consumption, exercise, body mass index, stroke, heart disease, hypertension, diabetes, and functional status.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

respondents in the rural-to-urban and urban-to-rural categories could have affected the results. These findings need to be further tested in larger samples.

In addition, we further assessed whether these associations can be explained by major sociodemographic, psychosocial, behavioral, and physiological risk factors. As discussed above, we found that socio-economic factors play a major role in explaining the differences in cognitive function across different migration groups. When all study variables (excluding SES) were included in the model, the results were the same as age-adjusted models (Model 1). We also performed sensitivity analyses that only included significant variables in the final model, and the results were essentially the same as those presented above.

Our findings also demonstrated that women consistently had lower cognitive function than men in both countries, which is consistent with the findings from prior literature. The gender differences in cognition that we found in China and India can be partially explained by the well documented gender inequality in economy, health, and education in both countries (World Economic Forum, 2017). We also found that Indian adults exhibited worse cognitive function than their Chinese counterparts. While limited prior research has particularly examined this topic, it is plausible that this finding is related to the fact that China is more economically developed and has a higher literacy rate than India (World Bank, 2018). Additionally, China demonstrates better performance on a variety of health metrics and higher health insurance coverage, which may partially explain the better cognitive function that we observed in the Chinese sample (GBD 2016 Causes of Death Collaborators et al., 2017; GBD 2016 Mortality Collaborators et al., 2017; GBD 2016 Risk Factors Collaborators et al., 2017; Goeppel, Frenz, Grabenhenrich, Keil, & Tinnemann, 2016). Similar to previous research (Oksuzyan et al., 2017), we found that the gender differences in cognitive function were larger in India than in China. We suspect that the larger gender differences may be due to a higher level of gender inequality in socioeconomic status in India (World Economic Forum, 2017). In our sample, we found a larger difference between men and women in the percentage of respondents with no education in India (Male: 29.7%, Female: 72.3%) compared to in China (Male: 12.6%, Female: 32.6%).

We acknowledge several limitations of this study. First, we recognize that the analyses were based on cross-sectional data. Therefore, the current findings should be interpreted with caution. We also acknowledge that the assessment of migration status was based on the

respondents' current location and most recent migration. Therefore, we were not able to capture multiple or "circular" migration in this study. Relatedly, we recognize that no information on the reasons for migration—a critical piece in an individual's migration history—was included in this study due to the data limitation in SAGE. In addition, we acknowledge the significant heterogeneity within urban and rural areas in these two countries. One previous study found that there were nonlinear associations between levels of urbanity and cognitive function in older adults (Wörn, Ellwardt, Aartsen, & Huisman, 2017). Due to lack of information on the level of urbanity and geo-location in SAGE, we were unable to assess the magnitude of the differences between current and previous places of residence. It is possible that migrating from a rural area to an urban setting in India involves greater changes in the physical and social environment than in China. In addition, we were unable to identify whether participants were cognitively impaired due to insufficient evidence on the cut-offs for the measures in our study population and no diagnosis information in SAGE. Although there is emerging evidence that migration patterns have different impacts on executive functions and recalls (Cassarino, O'Sullivan, Kenny, & Setti, 2016), due to limited measures on each cognitive domain in SAGE, we encourage future studies to incorporate more comprehensive cognitive tests to assess whether the associations between migration and cognitive function differ by cognitive domain. Finally, we lack data on genetic factors, environmental exposures, childhood circumstances, community characteristics, and other factors that are related to cognitive function. Therefore, we encourage additional studies to use longitudinal data to examine further the factors that may be contributing to the gender differences in the association between migration and cognitive function.

These findings have important implications that may be crucial to planning programs and policies to promote cognitive health in vulnerable populations in developing countries. Findings from this study provided new knowledge on health disparities in cognitive function among middle aged and older adults in China and India. Comparisons among groups with different migration status allowed us to examine how changes in environment might be associated with health status in later life. Future research that assesses health disparities in later-life cognitive function especially in LMICs should not only compare cognitive function between rural and urban residents, but also take into consideration of the internal migrant populations. In addition, health services need to consider that certain migration populations (e.g. rural-to-rural migrants) might be more vulnerable to cognitive impairment/decline. Therefore, primary health providers should promote and ideally employ early screening for potential cognitive impairment in these migrant populations. Our findings also demonstrated a significant gender disparity in later life cognitive function in both countries. Governments and NGOs in China, India, and other LMICs should continue the current programs to promote gender equality and to empower all women and girls in multiple aspects. In addition to that, more efforts are needed to help women and girls from rural areas achieve equitable access to educational attainment, employment opportunities, and health care. These programs and policies will potentially reduce gender disparities in cognitive function among middle aged and older adults in LMICs.

5. Conclusion

Increasing numbers of older adults with some levels of cognitive impairment have put great strain on the healthcare systems in China and India as well as other developing countries. We found women exhibit poorer cognitive function than men in both countries. We also found that migration is associated with cognitive function. This association varies by gender and country and the differences in cognitive function persist after adjustment for multiple risk factors. Results from our study also provide valuable new insights about factors that are associated with cognitive function among men and women in developing countries. Healthy aging policies in China and India should continue promoting gender equality and focus more on the vulnerable rural-to-rural migrant population.

Conflict of interest statement

We declare that there is no conflict of interest regarding any financial and personal relationships with other people or organizations that could inappropriately influence (bias) this work.

Acknowledgements

We acknowledge that this work has been accepted for oral presentation at the Gerontological Society of America 2018 Annual Scientific Meeting.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.archger.2018.11.011.

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