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Productive activities and cognitive decline among older adults in China: Evidence from the China Health and Retirement Longitudinal Study

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ABSTRACT

This study examines the relationship between productive activities and cognitive decline among older adults aged 50 years and over in China and whether this relationship varies by gender and urban/rural residence using a sample of 13,596 respondents from three waves of the China Health and Retirement Longitudinal Study. Results from Generalized Estimation Equations show that caring for grandchildren, caring for a spouse, informal helping and formal volunteering are associated with reduced risk of cognitive decline over a two-year period. In addition, the types of productive activities that are most beneficial for cognition vary by gender and urban/rural residence. Caring for grandchildren and volunteering are most beneficial for urban women, informal helping is most beneficial for urban men, and paid employment is most beneficial for rural men.

1. Introduction

With rapid population aging, Alzheimer's disease (and related dementias) is becoming a severe health problem for the older population in China. Due to its large population size, China already has more people with Alzheimer's disease than any country in the world. In 2010, an estimated 5.69 million Chinese had Alzheimer's disease and 9.19 million had dementia in China (Chan et al., 2013). By 2050, the World Health Organization projects that 10 million older Chinese will have dementia (Xiao et al., 2016). The rising prevalence of the disease, accompanied by a decline of families as the major source of eldercare and a lack of long term care facilities, poses challenges for older people, their families and society as a whole. Against this background, researchers are increasingly interested in finding out ways to help older Chinese maintain their cognitive function and slow down cognitive decline.

Recent research has shown that productive activity participation is associated with improved overall well-being and favorable health outcomes including a lower level of mortality, morbidity, and depression among older adults (Li et al., 2014; Liu and Lou, 2017). Productive activities refer to "any activity performed by an older adult that produces socially valued goods or services, whether paid for or not, or that develops the capacity to produce such goods or services" (Li et al., 2014, p. 785). Although there is lack of consensus on the breadth of activities counted as productive and how to operationalize them in the Chinese context, most previous studies have suggested that paid work, formal volunteering (including membership in voluntary associations), family caregiving, and informal help (providing help to others living outside the household such as neighbors, friends, and relatives) are the basic categories of productive activities (Li et al., 2014; Liu and Lou, 2017; Lum, 2013; Morrow-Howell, 2010). By performing these activities, older adults can make social and family contributions that benefit others, and meanwhile they can better integrate into their social networks and receive gratification (Liu and Lou, 2017; Peng and Fei, 2013). Previous prospective research suggests that social integration and social engagement are negatively associated with cognitive decline (Ertel et al., 2008; Kuiper et al., 2015). Yet, whether participation in productive activities has a protective effect on cognitive function among older adults is still not clear and the relevant evidence for older adults in China is limited.

We contribute to the current research by focusing on whether productive activities are associated with older adults' cognitive health in China, and we go beyond examining the cross-sectional association between productive activities and cognitive function and focus on the impact of productive activities on cognitive declines over time. In addition, we examine which types of productive activities are more beneficial to cognitive health. Furthermore, given the enormous socioeconomic disparities between rural and urban areas and gender differences in employment and caregiving activities, we also examine whether these associations vary by gender and urban/rural residence.

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2. Theoretical background

2.1. Productive activities and cognition

Participation in productive activities is shaped by the sociocultural context in which older adults are embedded (Morrow-Howell and Wang, 2013). The sociocultural context not only shapes the extent and types of productive activity engagement, but the compatibility of different activities (Liu and Lou, 2017). Role theory is one of the mainstay perspectives guiding research on productive aging. This theory consists of three perspectives: role loss, role strain, and role enhancement (Hao, 2008; Morrow-Howell, 2010). The role loss perspective posits that the sudden role loss individuals encounter when they move into older age may result in negative effects, especially when access to new roles is not concurrently available. This perspective is usually used to explain the psychological loss of retirement (Liu and Lou, 2017). Second, role strain perspective assumes that multiple roles in parallel resulting in an accumulation of conflicting role, for example, caregiving related obligations, overload, and strain will be harmful for health, especially mental health for older adults (Liu and Lou, 2017). In contrast, role enhancement perspective hypothesizes that a collection of multiple productive roles, due to opportunities for engaging with others through social networks, may lead to better well-being and quality of life among older adults. Caring for grandchildren, formal volunteering, and informal helping encompass features of role enhancement. Some evidence also shows that an active and engaged lifestyle can prevent cognitive impairment for older adults (Zhu et al., 2017). The cognitive reserve hypothesis suggests that an engaged lifestyle may enable related neural networks to be more efficient or plastic, which might slow cognitive deterioration (Stern, 2012). Although prior studies have applied role theory to explain the impact of multiple productive activities on overall well-being or mental health among older people, no study has focused on the impact of productive activities on cognitive decline for the older Chinese.

Despite limited evidence, productive activity participation was found to be associated with better health for older adults in China. For example, one study using cross-sectional data showed that working for pay in old age is associated with better self-reported health (Ling and Chi, 2008). In China, much fewer older adults are involved in volunteering activities compared to western countries due to different sociocultural contexts. The volunteer sector in China is mainly organized by the government organizations, and nongovernmental organizations' activities are restricted. Moreover, the government-led volunteer programs were formally launched in the 2000s and targeted mainly retired professionals (Chen et al., 2018; Mui, 2010). Despite such limited participation, two recent studies found that volunteering is associated with better mental and physical health (Li et al., 2014; Liu and Lou, 2017).

Chinese culture is family-oriented and mutual assistance is a cultural norm. Many Chinese older adults provide caregiving to their family members including their parents, spouses, and grandchildren. Grandparental childcare is particularly common in China (Sun, 2013). Research suggests that grandparental childcare experiences are a mixture of enjoyment and burden (Xu et al., 2017). Most studies found that caring for grandchildren is stressful, which leads to the development of depression, anxiety, hypertension, and cardiovascular diseases (Xu et al., 2017). Other studies revealed the beneficial effect of family caregiving such as the positive effects of grandparenting on psychological well-being for older adults in Taiwan and Hong Kong (Ku et al., 2013; Lou, 2011). Some suggested that the health impacts of grandparenting varies by coresidence and intensity of care (Chen and Liu, 2012). Yet, little evidence is available about whether grandchild caregiving is associated with cognitive function for older Chinese. Also, it is not clear whether caring for parents and a sick spouse would render the same consequences on cognitive function as caring for grandchildren. Additionally, informal helping such as helping friends and neighbors is also common in China, but seldom studied. One longitudinal study showed that informal helping has protective effects on mental health (Liu and Lou, 2017), but no longitudinal study has examined the association between informal helping and cognitive decline among older Chinese adults.

2.2. Gender and urban/rural differences

The impact of productive activities on cognitive function may differ by gender and urban/rural residence in China because gender and urban/rural residence are associated with role expectations and resources. Prior research showed that levels of productive activity participation vary by gender and urban/rural residence. In China, women are often expected by social norms to carry major responsibility for nurturing and caring for family members and they often have lower levels of education and income, and retire from their jobs earlier than men (Zhang et al., 2015). As a result, women are often constrained in their choices of activity participation due to financial and time limitations. In China, co-residence with adult children is a common living arrangement for older people, especially in rural areas where state welfare provisions have largely disappeared since the start of the economic reforms in the late 1970s and family members rely more on each other for care and assistance (Ren and Treiman, 2015; Zeng and Wang, 2003). In addition, rural grandparents are more likely than their urban peers to become custodial caregivers because of adult children's labor force migration from rural to urban areas (Xu, 2018). On the other hand, participation in social activities such as volunteering is more supported by policies and easier to access due to transportation facilities in urban areas than rural areas.

The gendered norm of paid work and caregiving suggests that caregiving may be more beneficial for women's health while paid employment may be more beneficial for men's health as each gender has acquired the skills and resources over the life course to appropriately fulfill their respective role in society and thus experiences less role strain if they are involved in the activity which is congruent with the traditional norm. Empirical findings on differential gender effects are mixed. For example, a study of older adults in Shanghai found that engagement in social activities is more beneficial for self-rated health and psychological well-being of older women than older men; however, it showed that caring for grandchildren has more beneficial effects for older men's health (Zhang et al., 2015). Xu and colleagues also found a stronger association between caring for grandchildren and physical and mental health among older men than women which they attributed to the fun-seeker, playmate, and companion role grandfathers played rather than fulfilling more intensive responsibilities, such as feeding, bathing, and dressing (Xu, 2018). Among grandparents who provided intensive grandchild care, grandfathers were found to experience a faster decline in self-rated health than grandmothers (Chen and Liu, 2012).

The beneficial effects of some productive activities may be tempered in rural areas as compared to urban areas. For example, although rural older adults, especially rural women, may be more accustomed to fulfilling caregiving obligations and coping with the associated physical and psychological strains, the greater demand associated with caregiving when few resources are available may deplete any health benefits of caregiving activities. In addition, those caring for grandchildren may be also more likely to be financially dependent on their adult children and consider grandchild care as a reciprocal form of intergenerational exchange instead of an emotionally rewarding, altruistic activity (Chen and Liu, 2012; Xu, 2018).

Based on the discussions above, we hypothesize that productive activities are associated with slower declines in cognition among older Chinese adults. We also hypothesize that these associations vary by activity type, gender, and urban/rural residence. While caregiving and volunteering may be more beneficial for women, especially urban women, employment may be more beneficial for men.

3. Methodology

3.1. Data

Data for this study came from three waves of the China Health and Retirement Longitudinal Study (CHARLS 2011–2015), which included computer-assisted in-person interviews with a nationally representative sample of adults 45 years and older, as well as their spouses when possible. The sample was obtained through four-stage stratified sampling, with an overall response rate of 80.5% at the baseline (Zhao et al., 2014). The baseline survey was conducted between June 2011 and March 2012 covering 28 provinces, 150 counties/districts, 450 communities, and 17,708 respondents from 10,257 households. Two follow-up interviews were conducted in 2013 and 2015. We restricted our analysis to the 13,651 respondents who were aged 50 years or older at the baseline survey since women can retire at age 50 in factories while the mandatory retirement age is 60 for men and 55 for female civil servants. We dropped 45 respondents who were unemployed at the 2011 survey because the number of cases was too small for detailed analysis by gender and urban/rural residence. We also dropped 10 respondents who were missing on gender. The remaining 13,596 respondents interviewed in 2011 include 2612 men and 2825 women in urban areas and 4116 men and 4043 women in rural areas. Among those interviewed in 2011, 11,779 were re-interviewed in 2013, and 10,498 were re-interviewed again in 2015. We used multiple imputation method for missing data due to item-nonresponse and lost to follow-ups in our regression analyses (see below for details).

3.2. Measures

3.2.1. Cognitive function

Cognitive function measures in all three waves were used in this study. CHARLS included similar items for cognitive function as those used in the U.S. Health and Retirement Study, which were components of the Telephone Interview of Cognitive Status (TICS) battery (Crimmins et al., 2011). The overall cognition score was the primary outcome of interest and was constructed by summing respondents' scores on all cognitive tests. It represents the respondent's cognitive status as a whole and ranged from 0 to 31. McArdle et al. (2007)'s study of the Health and Retirement Study data suggested two factors to adequately capture cognitive function: one factor related to episodic memory and a second factor related to other tasks of the TICS battery which they labeled as mental status (McArdle et al., 2007). Episodic memory is an important aspect of fluid intelligence which concerns learning performance and processing of new materials and tends to decline substantially in adulthood. The other tasks in the TICS contain elements of both fluid and crystallized intelligence (Hu et al., 2012). Because crystallized intelligence includes knowledge and skills accumulated in the past, which are not easily lost, productive activities may have greater impact on episodic memory than the other TICS tasks. Based upon this literature and recommendations from previous studies using the CHARLS data (Lei et al., 2014a,b), we also assessed the two components of cognitive function separately.

In CHARLS, episodic memory was assessed through an immediate word recall based on respondents' capacity to immediately repeat in any order ten Chinese nouns just read to them, followed by a delayed recall that tested respondents' ability to repeat the same list of words four minutes later. A single score of memory was calculated by summing the immediate and delayed recall scores, and it ranged from 0 to 20.

The other cognitive tests included items on orientation, visuoconstruction, and numeric ability. Orientation was assessed by asking respondents to name today's date (month, day, year), season, and identify the correct day of the week. Visuoconstruction was assessed by asking respondents to accurately re-draw a previously shown picture. Numeric ability was assessed through the serial sevens test which asked respondents to subtract 7 from 100 (up to five times) and whether additional explanation or an aid such as a paper and pencil was needed to complete the task. Scores on these items were aggregated into a single score that ranged from 0 to 11 and was labeled as mental status. For both measures, higher scores indicate better cognitive function.

3.2.2. Productive activities

Productive activities in 2011 and 2013 were included in our analyses. CHARLS included six productive activities: caring for grandchildren, caring for parents/parents in-law, caring for a spouse, informal helping, formal volunteering, and employment (Liu and Lou, 2016). (1) *Caring for grandchildren.* Based on CHARLS′ questions about caring for grandchildren in previous year, we indicated each respondent's grandchild caregiving status with three categories: having grandchildren, but not providing any care; providing care; and no grandchildren. (2) *Caring for parents/parents in-law*. Based on CHARLS′ questions about caring for parents/parents in-law in the previous year, we indicated each respondent's parent caregiving status with three categories: having parents/parents in-law, but not providing any care; providing care; and no living parents/parents in-law. (3) *Caring for spouse*. In CHARLS respondents who reported difficulties in managing any ADLs or IADLs were asked who helped them with these difficulties. If the spouse was reported as the primary helper, the spouse of this respondent was considered as spouse caregiver. We also included a separate category for those who had no spouse. (4) *Informal helping*. Respondents were asked whether they provided help to family, friends, or neighbors who did not live with them and whether they cared for a sick or disabled adult who did not live with them without being paid in the previous month. Respondents who had an affirmative answer to either question were considered as having provided informal help. (5) *Formal volunteering*. Respondents were asked whether they did voluntary or charity work and whether they took part in a community-related organization in the previous month. Respondents who had an affirmative answer to either question were considered as having formal volunteering. (6) *Employment status.* CHARLS asked respondents about a variety of different types of employment they engaged in and detailed questions on each type of employment. We constructed a variable indicating their current employment status which had five categories: agricultural work; nonagricultural employed; nonagricultural self-employed or family business; retired; and never worked.

3.2.3. Control variables

Given that productive activity participation and cognitive function are influenced by sociodemographic characteristics and health condition, we included gender, age in years at baseline survey, urban/rural residence, educational levels (illiterate, primary education, and secondary education and above), household expenditure, living arrangements (alone or with spouse, with children, with other relatives but no children), and functional limitations as control variables. Household expenditure, living arrangement and functional limitations in 2011 and 2013 were included in our analyses. To measure financial resources, we calculated the annual household expenditures which was shown as a better measure of economic resources available to the family than income in developing countries (Strauss and Thomas, 2007). The summed total of annual expenditures was log transformed in regression models. The number of functional limitations was calculated by counting the number of times the respondent reported having some difficulty with or could not do seven activities, including specific forms of ambulation, such as walking 1 km and climbing several flights of stairs without resting, or muscle movements, such as lifting or carrying weights over 10 Jin (5 kg) or picking up a small corn from a table. It ranged from 0 to 7.

3.3. Statistical analysis

We first calculated descriptive statistics for all respondents, and

Table 1
Descriptive statistics (CHARLS 2011–2105).

	All		Urban		Rural	
			Men	Women	Men	Women
	Mean/% (std)	N	Mean/% (std)	Mean/% (std)	Mean/% (std)	Mean/% (std)
Cognitive function in 2011	14.20 (5.51)	11061	16.51 (4.71)	14.88 (5.78)**	14.55 (4.98)^{aa}	11.83 (5.46)**^{aa}
Cognitive function in 2013	13.51 (6.02)	10660	16.17 (5.29)	14.34 (6.15)**	14.02 (5.43)^{aa}	10.96 (5.95)**^{aa}
Cognitive function in 2015	12.73 (6.09)	9874	15.50 (5.19)	13.58 (6.36)**	13.29 (5.47)^{aa}	10.26 (6.07)**^{aa}
Episodic memory Scores in 2011	6.71 (3.42)	11061	7.44 (3.36)	7.15 (3.66)**	6.54 (3.23)^{aa}	6.05 (3.32)**^{aa}
Episodic memory Scores in 2013	6.44 (3.63)	10660	7.39 (3.60)	6.98 (3.84)**	6.36 (3.41)^{aa}	5.66 (3.55)**^{aa}
Episodic memory Scores in 2015	5.73 (3.69)	9874	6.76 (3.60)	6.41 (3.85)**	5.59 (3.51)^{aa}	4.97 (3.62)**^{aa}
Mental status scores in 2011	7.21 (3.24)	12418	8.89 (2.42)	7.47 (3.20)**	7.76 (2.90)^{aa}	5.45 (3.25)**^{aa}
Mental status scores in 2013	7.06 (3.34)	10660	8.78 (2.55)	7.37 (3.19)**	7.67 (2.99)^{aa}	5.30 (3.37)**^{aa}
Mental status scores in 2015	6.99 (3.32)	9874	8.74 (2.47)	7.17 (3.29)**	7.70 (2.88)^{aa}	5.29 (3.38)**^{aa}
Productive Activities						
Care for grandchildren in 2011		13596				
No care	42.21%		40.01%	33.10%**	49.13%^{aa}	42.96%**^{aa}
Care	26.83%		23.09%	30.48%	23.49%	30.10%
No grandchildren	30.96%		36.91%	36.42%	27.38%	26.94%
Care for grandchildren in 2013		11739				
No care	46.51%		40.56%	37.86%**	52.03%^{aa}	49.8%**^{aa}
Care	35.91%		34.20%	39.61%	32.64%	37.84%
No grandchildren	17.58%		25.24%	22.54%	15.33%	12.36%
Care for parents in 2011		13596				
No care	29.63%		33.50%	27.54%**	31.41%^{aa}	26.79%**^{aa}
Care	7.88%		9.46%	9.17%	6.92%	6.93%
No living parents	62.49%		57.04%	63.29%	61.66%	66.29%
Care for parents in 2013		11739				
No care	12.68%		13.95%	11.51%*	13.94%^{aa}	11.43%**^{aa}
Care	5.13%		6.69%	6.26%	4.38%	4.27%
No living parents	82.19%		79.36%	82.23%	81.68%	84.29%
Care for spouse in 2011		13583				
No care	74.91%		84.26%	70.83%**	75.91%^{aa}	70.70%**^{aa}
Care	9.57%		7.58%	7.44%	11.86%	10.00%
No spouse	15.52%		8.16%	21.73%	12.23%	19.29%
Care for spouse in 2013		11739				
No care	69.88%		78.94%	67.09%**	67.79%^{aa}	66.50%**^{aa}
Care	15.80%		13.85%	11.95%	21.45%	13.67%
No spouse	14.32%		7.21%	20.96%	10.75%	17.83%
Informal helping in 2011	6.02%	12534	6.59%	5.36%+	6.87%	5.30%**
Informal helping in 2013	12.32%	10736	13.05%	13.62%	12.93%	10.50%**
Volunteering in 2011	1.76%	12534	3.42%	2.59%+	1.10%^{aa}	0.79%^{aa}
Volunteering in 2013	2.65%	10736	4.89%	4.78%	1.72%^{aa}	0.98%**^{aa}
Employment status in 2011		13429				
Retired	34.80%		44.39%	58.40%**	18.47%^{aa}	29.02%**^{aa}
Agricultural work	45.63%		21.77%	21.78%	62.39%	60.21%
Nonagricultural employed	11.15%		23.56%	8.45%	12.41%	3.81%
Nonagricultural self-employed	5.35%		8.79%	4.98%	5.41%	3.36%
Never worked	3.08%		1.48%	6.39%	1.32%	3.59%
Employment status in 2013		11548				
Retired	36.92%		47.25%	59.02%**	21.96%^{aa}	32.59%**^{aa}
Agricultural work	46.19%		21.89%	23.40%	60.23%	59.74%
Nonagricultural employed	9.69%		20.67%	7.26%	11.39%	3.27%
Nonagricultural self-employed	5.76%		9.56%	6.40%	6.01%	2.97%
Never worked	1.45%		0.63%	3.92%	0.41%	1.43%
Covariates						
Urban in 2011	39.99%	13596				
Female	50.51%	13596				
Age in 2011	62.32 (8.66)	13596	62.33 (8.58)	62.47 (9.02)	62.31 (8.37)	62.21 (8.73)
Education		13568				
No education	31.80%		8.64%	32.39%**	19.75%^{aa}	58.58%**^{aa}
Primary school	40.58%		41.00%	35.37%	51.45%	32.88%
Middle school and above	27.62%		50.36%	32.24%	28.80%	8.54%
HH expenditure (1K yuan) in 2011	20.35 (19.35)	13596	26.18 (22.00)	24.68 (21.54)**	17.27 (16.84)^{aa}	16.71 (16.62)^{aa}
HH expenditure (1K yuan) in 2013	22.44 (22.48)	11739	29.03 (25.01)	26.42 (24.41)**	19.84 (20.47)^{aa}	18.78 (20.31)*^{aa}
Living arrangement in 2011		13596				
Alone or spouse only	36.18%		36.60%	36.67%	36.59%^{aa}	35.15%^{aa}
With children	53.94%		55.21%	55.22%	52.24%	53.97%
With other relatives	9.88%		8.19%	8.11%	11.18%	10.88%
Living arrangement in 2013		11739				
Alone or spouse only	33.16%		33.68%	33.00%	33.73%^{aa}	32.40%^{aa}
With children	46.26%		47.77%	49.23%	43.92%	45.90%
With other relatives	20.57%		18.55%	17.77%	22.35%	21.70%

(*continued on next page*)

Table 1 (*continued*)

	All		Urban		Rural	
			Men	Women	Men	Women
	Mean/% (std)	N	Mean/% (std)	Mean/% (std)	Mean/% (std)	Mean/% (std)
Functional limitations in 2011	1.56 (1.84)	13518	1.09 (1.68)	1.64 (1.82)**	1.33 (1.73)[aa]	2.03 (1.93)**[aa]
Functional limitations in 2013	1.69 (1.85)	11640	1.20 (1.65)	1.86 (1.87)**	1.41 (1.76)[aa]	2.13 (1.92)**[aa]

**p < 0.01, *p < 0.05, + p < 0.1 (two-tailed test): significance test for gender difference within urban residents and within rural residents.
[aa] p < 0.01 (two-tailed test): significance test for urban/rural difference within each gender.

then stratified by gender and urban/rural residence. T-test for continuous variables and Chi-square test for categorical variables were used to test whether gender and urban/rural differences are statistically significant. We used a two-year interval dataset in which the unit of observation is the two-year interval between pairs of interviews (i.e., 2011–2013, 2013–2015) to assess the effects of productive activities on cognitive decline over a two-year period. To construct this dataset, we first created two separate datasets with one containing 2011 and 2013 waves and the other containing 2013 and 2015 waves. In the first dataset, we renamed variables in 2011 as Time 1 variables and variables in 2013 as Time 2 variables; in the second dataset, we renamed variables in 2013 as Time 1 variables and variables in 2015 as Time 2 variables. Then we pooled the two datasets together. The main reasons we used the pooled two-year interval dataset are to fully utilize the three waves of CHARLS and also to increase the sample size for some productive activity categories, such as informal helping and volunteering. In our preliminary analyses, we tested whether pooling two separate two-year interval datasets was valid by including interactions of an interval indicator and measures of productive activities and these interaction terms were not jointly significant, indicating that pooling is legitimate. We used the lagged dependent variable approach and modeled each cognition measure at Time 2 as a function of productive activities, corresponding cognition measure and other covariates at Time 1. The lagged dependent variable approach allows us to control for unobserved heterogeneity between individuals and reduced the potential for reverse causality since any unobserved factors that may explain the correlations between productive activities and cognitive function at Time 1 are accounted for (Johnson, 2005). These models essentially tested the effects of productive activities at Time 1 on the change in cognitive function between Time 1 and Time 2; a positive coefficient would indicate a smaller decline in cognitive function while a negative coefficient would indicate a greater decline in cognitive function over a two-year period.

For each cognition outcome, we first estimated the model for all respondents and then for each residence/gender subgroup. Because each respondent may contribute up to two intervals to the dataset, we estimated our models using Generalized Estimating Equations (GEE), which is a procedure that adjusts the standard errors of the parameter estimates to account for non-independence of observations by using the observed correlational structure of the data (Diggle et al., 2002; Liang and Zeger, 1986). We estimated the models using the *xtgee* procedure with an unstructured covariance matrix, the distributional family normal and robust standard errors in Stata Version 14. Robust standard errors allow the estimates to be valid even in the event of misspecification of the variance-correlation structure. To test whether the correlation at the household level may affect our estimates since both age-eligible respondents and their spouses were included in the model for all respondents, we also estimated a random effect model which took into account the nesting of individuals within households and the results were similar to those from the GEE model. In addition, to further address the endogeneity issue between productive activity participation and cognition, we reran our models excluding the respondents with very low cognition scores at the baseline survey (bottom 5%) and found similar results.

One common problem in longitudinal studies is that attrition from the baseline to the follow-up surveys and missing cases on study variables did not occur completely at random. Our preliminary analysis showed that males, older age, more functional limitations, lower cognitive function, not caring for spouse, no volunteering activities, and not working were associated with higher mortality risk, and younger age, urban residence, more education, living alone, no spouse, and not working were associated with higher probability of loss to follow-up. Thus, we used multiple imputation with chained equations (MICE) to replace those missing cases and adjust for this potential bias. MICE allowed us to use different regressions to impute different types of variables. We used depressive symptoms, chronic conditions, self-rated health, self-rated memory and other social activity participation as auxiliary variables and created 10 imputed datasets to adjust for the potential bias. The imputed datasets were analyzed separately, and the results were combined in a way that accounts for variation in the imputed values (Allison, 2001; Young and Johnson, 2015). We also ran regression models without imputing values for attrition and missing cases and using Heckman selection method to adjust for sample attrition which produced similar results.

4. Results

4.1. Descriptive statistics

Descriptive statistics are reported in Table 1. At the baseline survey in 2011, the average score was 14.20 for the overall cognition measure, 6.71 for episodic memory and 7.21 for mental status. All three cognitive measures declined in 2013 and further declined in 2015. Older men and women in urban areas scored higher than older men and women in rural areas on all three cognition measures and across all survey years. Within both urban and rural areas, men scored significantly higher than women on all three cognition measures and across all three survey years. Almost all gender/residence groups experienced declines in the cognitive measures in each follow-up survey.

At the baseline survey, there were significant gender and rural/urban differences in almost all productive activities except for informal helping in which there were no significant urban/rural differences within each gender and for volunteering in which there was no significant gender difference in rural areas. Among all respondents, 27% provided care to grandchildren in the past year, while 42% had grandchildren but did not provide care. Although the proportions of men and women in rural areas who cared for their grandchildren were not substantially different from their respective urban counterparts, surprisingly higher proportions of men and women in rural areas had grandchildren but did not report any care provision compared to their urban counterparts. Within both urban and rural areas, higher proportions of women cared for their grandchildren than men. About 8% of all respondents provided care to their parents or parents in-law and higher proportions of urban older adults did so than rural older adults. About 10% of all respondents reported care for their spouses. Similar proportions of urban men and urban women reported this care, but a higher proportion of urban men than urban women reported having living parents, but did not provide care. In rural areas, slightly higher

proportions of men than women reported both having provided care and having parents but not provided care.

Informal helping was provided by 6% of respondents, and it was more prevalent among older men than older women. Formal volunteering was a rare activity with less than 2% reporting this activity. It was more prevalent in urban areas, especially among urban men. For employment status, nearly half of the respondents engaged in agricultural work last year and about 16% engaged in nonagricultural work, among whom 11% were employed by others and 5% were self-employed or worked for family businesses. Nearly one-third of respondents had retired, and the proportion of older adults who were retired was twice as high in urban areas as in rural areas, and the proportion of women who were retired was higher than that of men.

The proportions of respondent who provided grandchild care, spousal care, informal helping and volunteering increased from 2011 to 2013. Gender and urban/rural differences in most productive activities were similar in 2011 and 2013.

There are also significant urban/rural differences and gender differences in sociodemographic characteristics and physical health status. Urban older men and women had higher education, higher household expenditures and fewer functional limitations than their rural counterparts, and older men had higher education, higher household expenditures and fewer functional limitations than older women. A higher proportion of rural older adults were living with relatives other than their own children than urban older adults.

4.2. Productive activities and cognitive decline

Results from the lagged dependent variable regressions of the overall cognition score for all respondents and for each gender/residence group are reported in Table 2. In the model for all respondents (Column 1), the coefficients of providing care to grandchildren at Time 1 (b = 0.165), providing care to spouse at Time 1 (b = 0.157), informal helping (b = 0.194) and formal volunteering (b = 0.455) were significantly positively associated with the overall cognition score at Time 2 controlling for the overall cognition score at Time 1, other productive activities and sociodemographic and health covariates. This means that respondents who provided care to grandchildren, provided care to a spouse, provided informal helping and engaged in a volunteering activity had a smaller decline in the overall cognition score over a two-year period than those who did not engage in these activities. In addition, those who had agricultural work in the past year had a greater decline in overall cognition (b = −0.176) than those who had retired but those who engaged in nonagricultural work and those who never worked were not significantly different from those who retired in the rate of cognition decline.

Results from separate regressions on each residence and gender group (Table 2, columns 2–5) show that controlling for the overall cognition score at Time 1 and other characteristics, caring for grandchildren had a significant positive association with the overall cognition score at Time 2 only for urban women, caring for a spouse had a significant positive association with the overall cognition score at Time 2 only for rural men, informal helping had a significant positive association with the overall cognition score at Time 2 only for urban men, and volunteering had a significant positive association with the overall cognition score at Time 2 only for urban women. The relationship between employment status and cognitive decline was less consistent. For urban men, those who had agricultural work and those who had nonagricultural employed work had a greater decline in overall cognition than those who retired. For urban women, only those who had agricultural work had a greater decline in overall cognition than those who retired. For rural men, those who had agricultural work and those who had nonagricultural self-employed work had a smaller decline in overall cognition. For rural women, those who retired were not significantly different from those in any of the other employment status categories in the rate of cognitive decline.

Table 3 presents regression results on episodic memory and mental status, also first for all respondents and then for each residence/gender group. For all respondents, controlling for other productive activities and other covariates, caring for grandchildren (b = 0.133), informal helping (b = 0.165) and volunteering (b = 0.463) had a significant association with two-year memory decline (Table 3, Column 1). Those who cared for their grandchildren, who provided informal help, and who engaged in a volunteering activity had a smaller decline in memory over a two-year period than those who did not engage in these activities. In addition, respondents who had agricultural work (b = −0.110) or non-agriculturally employed work (b = −0.145) in the past year had a greater decline in memory than those who retired. Results from separate regressions on each residence and gender group (Table 3, Columns 2–5) show that controlling for the episodic memory score at Time 1 and other characteristics, caring for grandchildren had a significant positive association with the memory score at Time 2 only for urban women, informal helping had a marginally significant and positive association with the memory score at Time 2 only for urban men, and volunteering had a significant positive association with the memory score at Time 2 only for urban women. For urban men, those who had agricultural work and those who had nonagricultural employed work had a greater decline in the memory score than those who retired. For urban women, only those who had agricultural work had a greater decline in the memory score than those who retired. For rural men and women, those who retired were not significantly different from those in any of the other employment status categories in the rate of memory decline.

For all respondents, controlling for other productive activities and other covariates, caring for grandchildren (b = 0.064), caring for spouse (b = 0.122) and informal helping (b = 0.109) had a significant association with two-year decline in mental status score (Table 3, Column 6). Those who cared for their grandchildren, those who cared for their spouse and those who provided informal help had a smaller decline in mental status score over a two-year period than those who did not engage in these activities. In addition, respondents who had agricultural work (b = −0.097) had a greater decline in mental status score than those who retired. Results from separate regressions on each residence and gender group (Table 3, Columns 7–10) show that controlling for the mental status score at Time 1 and other characteristics, caring for spouse had a marginally significant positive association with the mental status score at Time 2 for urban men and rural men, and informal helping had a significant positive association with the mental status score at Time 2 only for urban men. For urban men, those who had agricultural work had a greater decline in the mental status score than those who retired. For urban women, both those who had agricultural work and those who never worked for pay had a greater decline in the mental status score than those who retired. For rural men, those who were employed in all three types had smaller declines in the mental status score than those who retired.

Because most respondents still work between ages 50 and 59 while nearly half did not work after age 60, we conducted additional sensitivity analysis to test whether the relationship between productive activities and cognitive decline differs between older people aged 50–59 years and those aged 60 years and over by adding interaction terms between productive activity measures and a dichotomous variable representing the two age groups. A few interaction terms were statistically significant. When all respondents were included, only for those aged 50 to 59 agricultural work was associated with a faster decline than retirement in the overall cognition score (b = −0.383), episodic memory (b = −0.237), and mental status (b = −0.190), and only for those aged 60 and over nonagricultural self-employment was associated with a slower decline than retirement in the overall cognition score (b = 0.449) and in episodic memory (b = 0.292). For urban men, only among those aged 50 to 59 caring for a spouse was associated with a slower decline in the overall cognition score (b = 0.983) and in episodic memory (b = 0.629). For rural women, only among those age 60

Table 2
Unstandardized regression coefficients of overall cognition at Time 2 on productive activities, overall cognition at Time 1 and covariates.

	All	Urban Men	Urban Women	Rural Men	Rural Women
Caring for grandchildren at T1 (ref = no care)					
Care	0.165*	0.150	0.391*	0.182	0.003
	(2.377)	(0.869)	(2.293)	(1.522)	(0.022)
No grandchildren	−0.035	0.070	0.132	−0.152	−0.151
	(-0.467)	(0.431)	(0.794)	(-1.059)	(-1.009)
Caring for parents at T1 (ref = no care)					
Care	−0.038	−0.208	0.217	−0.295	0.112
	(-0.297)	(-0.795)	(0.798)	(-1.248)	(0.447)
No living parents	−0.099	−0.142	−0.065	0.015	−0.188
	(-1.283)	(-0.808)	(-0.363)	(0.117)	(-1.369)
Caring for spouse at T1 (ref = no care)					
Care	0.157+	0.362+	−0.208	0.268*	0.106
	(1.929)	(1.801)	(-1.045)	(1.977)	(0.664)
No spouse	−0.336**	−0.576*	−0.278+	−0.351*	−0.246
	(-3.713)	(-2.130)	(-1.657)	(-2.070)	(-1.639)
Informal helping at T1	0.194*	0.435*	0.139	0.158	0.089
	(2.026)	(2.083)	(0.668)	(0.909)	(0.460)
Volunteering at T1	0.455*	0.194	0.742*	0.317	0.241
	(2.553)	(0.590)	(2.461)	(0.861)	(0.466)
Employment status at T1 (ref = retired)					
Agricultural work	−0.176*	−0.601**	−0.525**	0.250+	−0.043
	(-2.287)	(-3.308)	(-3.211)	(1.712)	(-0.338)
Nonagricultural employed	−0.153	−0.364*	−0.108	0.266	−0.046
	(-1.380)	(-2.046)	(-0.444)	(1.149)	(-0.163)
Nonagricultural self-employed	0.182	−0.072	0.349	0.618**	0.083
	(1.411)	(-0.323)	(1.148)	(2.596)	(0.290)
Never worked	−0.097	−0.488	−0.348	0.420	0.284
	(-0.404)	(-0.675)	(-1.094)	(0.709)	(0.691)
Female	−0.109+				
	(-1.682)				
Urban	0.661**				
	(10.825)				
Age	−0.078**	−0.071**	−0.081**	−0.074**	−0.087**
	(-15.313)	(-6.322)	(-6.919)	(-8.576)	(-10.110)
Education (ref = no education)					
Primary	2.036**	2.258**	2.041**	1.745**	2.042**
	(24.304)	(8.137)	(12.308)	(10.451)	(15.608)
Middle and more	3.224**	3.507**	3.435**	2.766**	3.305**
	(29.445)	(11.698)	(16.955)	(14.003)	(15.743)
Living Arrangement at T1 (ref = along or with spouse)					
With children	−0.268**	−0.121	−0.393**	−0.223+	−0.306*
	(-3.603)	(-0.780)	(-2.713)	(-1.802)	(-2.409)
With other relatives	−0.108	0.031	−0.384+	−0.133	−0.002
	(-1.258)	(0.142)	(-1.690)	(-0.869)	(-0.012)
Ln(HH Expenditure) at T1	0.014	0.017	−0.006	0.031	0.011
	(0.823)	(0.471)	(-0.193)	(0.818)	(0.366)
Functional limitations at T1	−0.127**	−0.211**	−0.106**	−0.172**	−0.046+
	(-6.964)	(-4.289)	(-2.918)	(-5.001)	(-1.688)
2013–2015 interval (ref = 2011–2013 interval)	−0.608**	−0.758**	−0.560**	−0.693**	−0.464**
	(-9.586)	(-5.678)	(-3.781)	(-6.267)	(-3.702)
Overall cognition at T1	0.576**	0.539**	0.577**	0.565**	0.589**
	(61.113)	(28.694)	(33.804)	(33.570)	(35.892)
Constant	8.745**	9.467**	9.620**	8.456**	8.826**
	(21.187)	(10.371)	(11.059)	(11.420)	(12.688)
Observations	25,302	4710	5100	7781	7711
Number of individuals	13,575	2607	2818	4111	4039
F	1367	154.6	352.7	307.4	428
df1	23	21	21	21	21
df2	2840	3173	3225	2898	3543

Note: Results were based on two-year interval dataset. Robust z statistics in parentheses.
**p < 0.01, *p < 0.05, + p < 0.1 (two-tailed test).

and over caring for grandchildren was associated with a slower decline in the overall cognition score (b = 0.315) and in mental status (b = 0.198).

In additional regression analysis, we differentiated levels of productive activity engagement by considering those who provided 40 weeks of grandchild care, 40 weeks of parental care, or weekly informal helping, and those who worked 40 hours or more per week or 32 or more weeks in the previous year as having a higher level of engagement, and the results are presented in a supplementary table online. There were very few significant differences between those with a low level of engagement and those with a high level of engagement in the rate of cognitive decline.

5. Discussion

This study advances the knowledge on productive activities and

Table 3
Unstandardized regression coefficients of episodic memory and mental status at Time 2 on productive activities, episodic memory and mental status at Time 1 and covariates.

	Episodic Memory					Mental Status				
	All	Urban Men	Urban Women	Rural Men	Rural Women	All	Urban Men	Urban Women	Rural Men	Rural Women
Caring for grandchildren at T1 (ref = no care)										
Care	0.133*	0.170	0.328**	0.143	−0.030	0.064+	0.021	0.137	0.059	0.033
	(2.531)	(1.294)	(2.672)	(1.633)	(-0.332)	(1.825)	(0.257)	(1.578)	(0.948)	(0.513)
No grandchildren	0.004	0.106	0.097	−0.089	−0.070	−0.026	−0.012	0.062	−0.078	−0.063
	(0.072)	(0.830)	(0.785)	(-0.854)	(-0.639)	(-0.696)	(-0.147)	(0.694)	(-1.073)	(-0.809)
Caring for parents at T1 (ref = no care)										
Care	0.035	−0.106	0.152	−0.065	0.113	−0.019	−0.046	0.152	−0.209+	0.047
	(0.367)	(-0.545)	(0.701)	(-0.368)	(0.611)	(-0.289)	(-0.366)	(1.145)	(-1.769)	(0.358)
No living parents	−0.060	−0.090	−0.032	0.011	−0.127	−0.026	−0.049	−0.005	0.033	−0.074
	(-1.013)	(-0.669)	(-0.231)	(0.114)	(-1.262)	(-0.705)	(-0.604)	(-0.052)	(0.512)	(-1.020)
Caring for spouse at T1 (ref = no care)										
Care	0.035	0.150	−0.249+	0.142	0.017	0.122**	0.201+	0.034	0.127+	0.101
	(0.589)	(1.029)	(-1.728)	(1.448)	(0.150)	(2.697)	(1.900)	(0.301)	(1.749)	(1.109)
No spouse	−0.235**	−0.310	−0.236+	−0.236+	−0.150	−0.131**	−0.311*	−0.085	−0.127	−0.101
	(-3.671)	(-1.583)	(-1.885)	(-1.846)	(-1.318)	(-2.705)	(-2.169)	(-0.889)	(-1.389)	(-1.279)
Informal helping at T1	0.165*	0.288+	0.167	0.176	0.056	0.109*	0.222*	−0.002	0.048	0.140
	(2.277)	(1.686)	(1.052)	(1.395)	(0.396)	(2.195)	(2.315)	(-0.022)	(0.546)	(1.330)
Volunteering at T1	0.463**	0.268	0.714**	0.076	0.497	0.130	0.016	0.215	0.335	−0.178
	(3.386)	(1.080)	(3.000)	(0.288)	(1.409)	(1.405)	(0.104)	(1.361)	(1.481)	(-0.561)
Employment status at T1 (ref = retired)										
Agricultural work	−0.110*	−0.456**	−0.306**	0.061	0.064	−0.097*	−0.239*	−0.305**	0.217**	−0.089
	(-2.065)	(-3.471)	(-2.591)	(0.574)	(0.724)	(-2.310)	(-2.474)	(-3.114)	(2.649)	(-1.228)
Nonagricultural employed	−0.145+	−0.292*	0.036	−0.034	−0.054	−0.011	−0.111	−0.144	0.374**	0.003
	(-1.735)	(-2.129)	(0.204)	(-0.194)	(-0.267)	(-0.208)	(-1.131)	(-1.161)	(3.427)	(0.021)
Nonagricultural self-employed	0.082	−0.079	0.293	0.277	−0.061	0.095	−0.026	0.018	0.403**	0.205
	(0.859)	(-0.466)	(1.315)	(1.560)	(-0.281)	(1.360)	(-0.208)	(0.124)	(3.210)	(1.236)
Never worked	0.011	−0.099	−0.006	0.233	0.174	−0.134	−0.484	−0.380*	0.286	0.126
	(0.068)	(-0.176)	(-0.030)	(0.554)	(0.606)	(-1.066)	(-1.245)	(-2.180)	(0.832)	(0.639)

Note: Results were based on two-year interval dataset. Age, education, living arrangement, household expenditure, functional limitations, and corresponding cognition measure at Time 1 are included in all models, but not shown in the table. Robust z statistics in parentheses.
**p < 0.01, *p < 0.05, + p < 0.1 (two-tailed tests).

their health consequences in several important ways. First, we focused on cognitive function, which is a largely understudied health outcome in the existing literature on productive activities for older adults, compared to physical health and psychological well-being. Second, we used large nationally representative longitudinal survey data and modeled changes in cognitive function so that the findings are more generalizable to a wider population in China and might help suggest the potential causal direction. Third, this study conducted detailed analysis of the associations between productive activities and cognitive decline within each gender and residence group. This is very important given the gendered nature of productive activity participation and the enormous urban-rural division in economic and welfare resources in the country.

The finding that caring for grandchildren, caring for a spouse, informal helping and formal volunteering are associated with reduced risk of cognitive decline over a two-year period is consistent with the role enhancement theory and supports our hypothesis. Volunteering, providing informal help, and even caring for grandchildren might promote an active lifestyle in older adults and allow them to gain social support, especially emotional support by engaging with others through social networks. During this process, adults can also practice their cognitive skills in thinking, learning, and reasoning, which might strengthen their cognitive function (Stern, 2012). In addition, we found some support for our hypothesis that the types of productive activities that are most beneficial for cognition vary by gender and urban/rural residence. For example, caring for grandchildren and volunteering are most beneficial for urban women, and paid employment is most beneficial for rural men, but none of these productive activities are significantly associated with rural women's cognitive decline. These findings suggest that both gender norms and demands/resources play a role in shaping not only the levels of activity participation, but also the consequences of such participation (Xu, 2018; Zhang et al., 2015).

The finding that caring for parents/parents in-law is not associated with cognitive decline is not surprising given that the respondents in CHARLS were relatively younger and the majority of them were still working, and thus caring for parents could be burdensome and take a toll on their health which might have cancelled out the benefits of caregiving. The finding that informal helping is most beneficial for urban men is somewhat surprising. This may be due to different activities involved in men's and women's informal helping. It is possible that men's informal helping (e.g., repair work, gardening, etc.) is more voluntary, less intensive, and more socially recognized than women's (e.g., caring for sick relatives) and thus is more beneficial for health and well-being. Future research needs to examine the types of informal helping activities that older men and women engage in.

The relationship between employment status and cognitive decline is more complex. On the one hand, employment is associated with slower declines in the overall cognitive function score and in mental status for rural men, but not for rural women. This is consistent with the role enhancement theory and gendered role expectations. Employment, as a productive activity, can enhance the social role for men and the support derived from work protects men's cognitive function from declining. Rural women, however, do not derive the same benefit from employment as rural men. Rural women tend to constrain their roles within the family as caregivers and the benefits they derive from caregiving are likely to be limited due to the lack of resources. On the other hand, contrary to our hypothesis, employment is not associated with slower declines in cognitive function for urban men. This may be explained by different retirement behaviors in urban and rural areas. Recent studies showed that while most workers in urban China retire at the official retirement ages (55 for women and 60 for men) and enjoy pension in retirement, most people in rural China continue working

until they are no longer physically capable (Giles et al., 2012). Better health conditions and more financial resources may reduce urban retirees' risk of cognitive decline.

Another interesting finding is that engaging in agricultural work is associated with greater cognitive declines for both men and women in urban areas, but engaging in nonagricultural work is associated with smaller cognitive declines for rural men. It is possible that older adults engaging in agricultural work in urban areas are rural migrants who face special challenges and stressors in urban China. Older adults with nonagricultural employment in rural areas are more educated and earn higher income both of which are important protective factors for health (Song and Logan, 2010). Nonagricultural self-employment in rural areas may be particularly challenging as it may require different cognitive skills to conduct daily operation. More research is needed to investigate the mechanisms underlying these associations.

This study has several limitations. First, our measures of productive activities are comprehensive, but still limited. For example, we do not have measures of engagement in housework. Caring for a spouse was based on responses to ADLs and IADLs which did not fully capture couple's daily interactions and support. Also, formal volunteering and informal helping questions were asked about the previous month which may have led to underestimating the prevalence of these activities. In addition, our analysis of the length and intensity of productive activity engagement is less thorough due to data availability and small number of participants in some activities, such as informal helping and formal volunteering. Second, although this analysis covered a four-year period, it might still be too short to see large cognitive declines. As new waves are being added in the future, it is important to reexamine these relationships. In the meantime, with longer periods, sample attrition due to mortality and dropout must be carefully evaluated and adjusted as the association may be less apparent due to the fact those who are less engaged and who have poor cognitive function are more likely to die or dropout.

Despite these limitations, our findings add to the growing literature on the beneficial effects of productive activities on older adults' health. Our findings highlight the role of productive engagement in protecting declines in cognitive function among older adults in China. These findings have implications for policy-makers, health care practitioners, and community advocates. Given the benefits of certain activities, such as informal helping and formal volunteering, efforts should be made to reduce barriers to participation in these activities. However, the negative effects, or lack of positive effects, of certain productive activities, such as employment and caring for aging parents, should be carefully evaluated and effort should be made to modify older adults' experiences in these activities to prevent their harmful effects on cognitive function. In addition, as data from the CHARLS suggest, there is a large divide between urban and rural residents and between men and women in their productive activity participation and in their cognition. Social policies need to take into consideration these divisions and their implications for productive aging. In practice, more social activities need to be created, provided, and delivered to people in rural China. And, social programs and interventions should meet the needs of different genders and people who live in different geographic locations.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2018.09.052.

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