Cognitive and psychological health implications of living alone among middle-aged and older adults in China

Ming Wen, PhD
Professor
Department of Sociology
University of Utah
380 S 1530 E Rm 301
Salt Lake City, UT 84093
ming.wen@soc.utah.edu

Qiang Ren, PhD
Associate Professor
Center for Social Research
Peking University
Beijing, China
renqiang@pku.edu.cn

Abstract

This study examines the associations between living alone and psychological and cognitive health and explores the moderating effects of age, gender, marital status, social engagement and family income among middle-aged and older adults in China. Data are from a longitudinal sample of 9,469 participants in the 2010 and 2014 waves of the China Family Panel Study. Cognitive health is captured by word and math test scores. Psychological health is measured by depressive symptoms. The results show that living alone has no health benefits in this sample of middle-aged and older Chinese but seems injurious for psychological health among the unmarried and detrimental to cognitive health for men. Study implications are discussed. More research is needed to explore the mediating and moderating effects of the link between living alone and health.

Key words: living arrangement, cognitive health, depressive symptoms, middle-aged, older adults.

Background

China is aging fast after nearly four decades of implementing the "one child per family" policy and seeing rapid economic development and increased life expectancy during the reform and opening era. Between 1970 and 2015, the population aged 50+ years in China grew substantially from 111.37 million to 396.85 million, constituting nearly 29% of the entire Chinese population (Knoema, 2015). China's aging is typically perceived as an unfavorable demographic trend by researchers and investors, considering the challenges of economic support and elderly care concomitant with an aging population (Heshmati, 2016). Presumably, healthy aging can help alleviate the pressure on both families and communities.

Health as human capital (Gardner & Gardner, 2012) is considered to be an important determinant of socioeconomic achievements for an individual (Muennig, 2008) and economic productivity for a country (Heshmati, 2016). While China has made considerable strides in raising the average life expectancy at birth from 66.5 years in 1980 to 75.7 years in 2018, it still falls close to four years short of the average of 79.6 years in high-income countries. Moreover, China's elders are found to have relatively poorer health on many health indicators by international standards (Smith, Strauss, & Zhao, 2014). More research needs to be done to examine social determinants of health among middle-aged and older adults in China to provide evidence that can be used for developing measures to enhance healthy aging in China.

Rapid industrialization and spectacular economic growth have significantly improved social conditions in China, making a positive contribution to healthy aging (Smith et al., 2014). Meanwhile, the living arrangements of Chinese people are also changing rapidly. Due to lifestyle changes, dramatic declines in family size, and large increases in internal and international migration, the total population living alone increased from 17 million in 1982 to approximately

59 million in 2011 (Cheung & Yeung, 2015) and is expected to further increase to 162 million in 2050 (Yeung & Cheung, 2015). The proportion of adults aged 65 or older living alone is also expected to increase from 3.6% in 2010 to 12.5% in 2050 (Yeung, Feng, Wang, & Zeng, 2016). In 2015, approximately 1.9 million seniors lived in one-person households (OPH) in China (Yeung et al., 2016).

In this study, we aim to investigate the implications of living alone for cognitive and psychological health among middle-aged and older adults in China. We extend previous research by including the middle-aged in the sample, addressing cognitive health as an under-researched outcome in this literature, and exploring whether age, gender, marital status, social engagement, and income modify the influence of living alone on cognitive and psychological health. Cognitive health, the ability to clearly think, learn, and remember, is an important part of healthy aging. Cognitive decline, mild impairment and dementia undermines productivity and independence. Improving cognitive health particularly among older adults has become an emerging public health priority in the U.S. (Alzheimer's Association & Centers for Disease Control and Prevention, 2013). We also focus on psychological health because of its impacts on the quality of life of individuals and their loved ones and because mental disorders are the leading cause of years lived with disability worldwide (Ferrari et al., 2013).

Background

Theoretical perspectives

For health and well-being, living alone is commonly perceived as worrisome based on the widespread belief that humans are naturally oriented toward others and wired to connect (Christakis & Fowler, 2009). However, a 7-year qualitative study conducted in the U.S. revealed that living alone is not an entirely solitary experience; rather, in this study those living alone

tended to be more socially active and civically engaged and enjoy a more rich and varied life experience (Klinenberg, 2012). There was a clear distinction between living alone and being alone in this study. Nevertheless, while thought-provoking, these findings are not necessarily generalizable to other U.S. settings or other cultures.

In theory, living alone can have both pros and cons. On one hand, living alone can be linked with feelings of isolation, anger, social exclusion and a lack of social support, limited engagement in social activity, and economic deficiency, which have all been associated with poorer health (Evans et al., 2019; Pulkki-Raback et al., 2012l; Stepler, 2016; Yu, Hou, & Miller, 2018). On the other hand, solo-dwellers do not necessarily feel lonely or socially isolated, and may even be more socially engaged outside of the household because they are less involved in the household and probably have more time for socializing with friends. Living alone can also offer autonomy and nurture independence, give the time and freedom to explore individual passions, and provide opportunities for self-discovery and relaxation without distractions or home conflicts. These perspectives are arguably applicable to both cognitive and psychological health.

Moreover, the health implications of living alone can vary according to sociodemographic factors that directly influence the consequences of living alone. For example, advancing age may exacerbate issues of living alone like lacking social support because older people are more likely to suffer from disease, frailty, functional limitation, and dependency (Y. Chen & While, 2019). Meanwhile, living alone may be less detrimental to women's well-being than to men's because women tend to maintain more active social ties to friends and relatives and tend to report higher levels of social support, regardless of their marital status or living arrangement (Michael, Berkman, Colditz, & Kawachi, 2001; Reissman, 1990; Turner & Marino,

1994). Living alone may also be less consequential to those who remain socially engaged given that the challenge of living alone can be mitigated by social interactions (Zebhauser et al., 2015). Among the solo-dwellers, those who are married are likely more advantaged due to the various resources available through marriage. Financial resources may be another moderator, given that a substantial number of individuals living alone in the U.S. report feeling less comfortable about their financial situation (Stepler, 2016) and that the effects of financial hardship on health outcomes are well documented (Chokshi, 2018). These potential moderating effects of sociodemographic characteristics add theoretical complexity to expectations about how living alone affects health.

Consistent with the conceptual ambiguity, evidence is mixed and inconclusive. The literature on living alone and psychological health is more extensive than that on living alone and cognitive health. The majority of published studies relevant to these topics have been conducted among non-Chinese populations and included adults aged 60 or older. Fewer studies have attempted to identify socio-demographic characteristics that may moderate the association between living alone and health.

Evidence on living alone and psychological health

In terms of psychological health, some authors report that living alone is positively associated with depressive symptoms (Fukunaga et al., 2012; Lee & Hong, 2016; McLaren, 2016; Mouodi, Bijani, Hosseini, & Hajian-Tilaki, 2016; Park, Jang, Lee, & Chiriboga, 2017), whereas others find living alone is linked to lower levels of negative emotions (Glick, 1994; Ng, Lee, & Chi, 2004; Oh, Kim, & Hong, 2009; Osborn et al., 2003; Schieman, 1999) or has no effect on depressive symptoms after confounding factors are accounted for (Chou, Ho, & Chi, 2006; Jeon, Choi, & Cho, 2017; Osborn et al., 2003).

Little work has been done to evaluate how age, marital status and income may moderate the effects of living alone on psychological health. More research has been done to evaluate the moderating effects of gender and social engagement. There is converging evidence that living alone is more detrimental to psychological health for men than for women (Hughes & Waite, 2002; Jeon, Jang, Rhee, Kawachi, & Cho, 2007; Kim, 2009; Michael et al., 2001; Russell & Taylor, 2009), and that socio-relationship resources encompassing constructs such as social engagement, social support and social networking reduce the detrimental effects of living alone on psychological health (Barrett, 1999; Fukunaga et al., 2012; Russell & Taylor, 2009).

Findings from China-based studies mostly point to a negative association between living alone and psychological well-being (Cheng, Fung, & Chan, 2008; Chou et al., 2006; Li, Zhang, Shao, Qi, & Tian, 2014; Q. Ren & Treiman, 2015), although a study conducted in Hong Kong found no effect of living alone on psychological health (Ng et al., 2004). A recent review of the China-based research on living alone and depressive symptoms indicated that social support and social engagement lessened the levels of depressive symptoms among empty-nested Chinese elders (Sun, Yu, & Li, 2018). Most studies have been cross-sectional and small in scale, and used non-probability samples. Evidence is not readily available from China as to socio-demographic characteristics may moderate the effects of living alone on psychological health.

Evidence on living alone and cognitive health

Cognitive health or function has been measured in many different ways. As measures of global cognitive functioning, the Mini-Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975) and standardized MMSE (Molloy, Alemayehu, & Roberts, 1991) have been the most commonly used cognitive screening tools (Woodford & George, 2007). Many other cognitive performance tests or cognitive assessment batteries are available. For example, the

Cambridge Cognitive Examination (CAMCOG) (Roth et al., 1986) and the Short Portable Mental Status Questionnaire (SPMSQ) (Pfeiffer, 1975) have both been used to assess the relationship between living arrangement and cognitive abilities in community-dwelling, non-clinical populations (Evans et al., 2019). The CAMCOG is a comprehensive standardized instrument used to measure the extent of dementia, and to assess the level of cognitive impairment; it shares the components of the MMSE but also tests additional cognitive aspects including calculation. By contrast, the SPMSQ is a 10-item brief cognitive screening instrument (Roccaforte, Burke, Bayer, & Wengel, 1994). A host of cognitive tests including the CAMCOG and SAPMSQ are found to be significantly correlated with the MMSE (Heinik, Solomesh, & Berkman, 2004; Woodford & George, 2007), which is also significantly correlated with various tests on literacy, vocabulary or reading ability capturing crystallized intelligence (Barnes, Tager, Satariano, & Yaffe, 2004; Dykiert, Der, Starr, & Deary, 2016; Whitney, Maoz, Hook, Steiner, & Bieliauskas, 2007).

Previous research has shown that having diverse social ties (Bassuk, Glass, & Berkman, 1999; Berkman, 2000) and strong social support and following an active and socially integrated lifestyle (Krueger et al., 2009) are critically protective against cognitive decline in later life. It has thus been postulated that living with others might imply more opportunities to experience social and intellectual challenges that can mobilize brain activities and strengthen brain capacity and cognitive reserve, which may help prevent cognitive decline or delay the onset of cognitive impairment (Hakansson et al., 2009; Stern, 2012). Alternatively, it is also possible that living alone forces the individual to deal with daily living tasks alone and can promote independence and self-efficacy.

Findings from studies that assess the effects of living alone on cognitive health are inconsistent. While some studies report a significant association between living alone and poorer cognitive health (Evans et al., 2019; Gow, Corley, Starr, & Deary, 2013; Hakansson et al., 2009; Jung & Kim, 2004; Mazzuco, Meggiolaro, Ongaro, & Toffolutti, 2016; van Gelder et al., 2006; Yaffe et al., 2009), others document no effect of living alone on cognitive health (Conroy, Golden, Jeffares, O'Neill, & McGee, 2010; Evans et al., 2019; Josefsson, de Luna, Daniels, & Nyberg, 2016) or some aspects of intelligence (Gow et al., 2013; Mazzuco et al., 2016). With a few exceptions (Evans et al., 2019; Mazzuco et al., 2016; van Gelder et al., 2006; Yaffe et al., 2009), most studies are cross-sectional.

Previous research examining how sociodemographic characteristics may moderate the link between living alone and cognitive health is limited. A number of studies report that socio-relational resources manifested in constructs like social engagement, social connection, and social support predict better cognitive health among older adults (Bassuk et al., 1999; Holtzman et al., 2004; Krueger et al., 2009; MacNeill, Bank, & Lichtenberg, 2002; Zunzunegui, Alvarado, Del Ser, & Otero, 2003), implying that rich socio-relational resources or social capital (Wen, 2017) may mitigate the detrimental effects of living alone on cognitive health, if they exist to begin with.

Little work has been done in China to examine the link between living alone and cognitive health. Being unmarried (L. Ren et al., 2018) and loneliness (Zhong, Chen, & Conwell, 2016; Zhong, Chen, Tu, & Conwell, 2017) have been found to be risk factors of cognitive decline among older Chinese. However, marital status and loneliness are distinct constructs from living alone. The cognitive health benefits of social engagement have been reported (Mortimer et al., 2012; Zhou, Wang, & Fang, 2018), but no evidence is available as to whether social

engagement can moderate the link between living alone and cognitive health. The limited literature on this matter underscores the need for more research on the health implications of living alone in China.

The Current Study

Given the theoretical and empirical background, the primary objective of this study is to investigate whether living alone and living with others have differential prospective implications for psychological and cognitive health among middle-aged and older Chinese. Our hypothesis is that living with others is more beneficial than living alone. Our second objective is to examine the moderating effects of five sociodemographic factors including age, gender, marital status, social engagement, and family income. We expect the detrimental health effects of living alone, if observed, to be worse for older, men, unmarried, socially inactive, and poorer individuals compared to their respective counterparts.

Methods

Data

Data used in this analysis were from the 2010 and 2014 waves of the *China Family Panel Studies* (CFPS), a national probability sample of Chinese families. Interviews were conducted with all family members age 10 or older (Xie & Hu, 2014). In the 2010 wave, there were 13,485 CFPS participants 50 years old or older, among whom 10,295 were successfully recruited for the 2014 wave. The attrition between the 2010 sample and the 2014 sample was 3,190. After deleting 826 cases missing value in at least one of the variables included in our analyses, 9,469 study participants remained in the analytical sample, followed up for 2 years, constituting 18,938 person-years. Among the 3,190 losses-to-follow-up, 765 died sometime between 2010 and 2014, 686 did not participate in the 2014 wave due to being out of town or other unknown reasons (but

talked to the interviewer), and the other 1,739 individuals were lost to follow-up for unknown reasons. We did not use CFPS data from the 2012 wave because questions asked for psychological and cognitive health in 2012 were different from those asked in 2010 and 2014. Our sample was restricted to 18,958 observations of 9,469 people and age 50 or older who were interviewed in both waves and responded to all the variables included in the analysis (see Table 1). The analytical sample of 9,469 participants and the dropped sample of 4,016 (3,190+826) participants did not differ substantially in the distributions of living alone and marriage.

Dependent variables

Psychological health was measured by depressive symptoms. Six items adapted from the CES-D scale (Radloff, 1991) were used to construct a scale of depression, which has been validated for studies of Chinese adolescents (Z. Chen, Yang, & Li, 2009). For each item, respondents were asked how often they felt this way during the past month: almost every day (5), two or three times a week (4), two or three times a month (3), once a month (2), or never (1). The scale was constructed by summing item responses, with values ranging from 6 to 30. The resulting scale is reasonably reliable, with Cronbach's alpha equal to 0.87 in both 2010 and 2014 waves.

Cognitive status was captured by vocabulary and numeracy measures assessing respondents' verbal and mathematical achievements and representing "crystallized intelligence," which is defined as acquired knowledge through learning, experience, and education (Cattell, 1987). The test items were drawn from the standard curricula in primary and secondary schools (Xu & Yu, 2015). Crystallized intelligence is correlated with "fluid intelligence," the abilities to reason abstractly and to solve problems without drawing upon previously acquired skills or knowledge (Cattell, 1987). Both types of intelligence measures were found to be related to key

demographic and social characteristics, such as age, gender, education, and rural-urban residence (Xu & Yu, 2015). In the 2014 wave, only the crystallized intelligence measures were available.

In the vocabulary or word test, the number of words correctly read out loud from a list of 34 words was used to assess the participant's vocabulary knowledge, a measure of intellectual competence net of years of schooling. The word test scores ranged from 0 to 34. Since Chinese is an ideographic language, it is not possible to guess at the pronunciation of a word from features of the character(s) representing the word; each word must be memorized in the same way that Arabic numerals must be memorized.

The numeracy or math test included 24 mathematical items, presented in order of increasing difficulty. Respondents were assigned to one of three entry points, based on their highest level of education. Those with primary school education or less started with the first problem (i.e., the easiest one), junior middle school graduates started with the fifth problem, and senior middle school graduates and those with more education started with the thirteenth problem. The test continued until a respondent failed three consecutive problems (Huang, Xie, & Xu, 2015). The math test scores ranged from 0 to 24.

Independent variables

The key predictor in our study is living alone versus not living alone. In the fixed effects models, we controlled for age (50-59, 60-79, and 80+), marital status (currently not married vs currently married), family income per capita (yuan; rescaled as family income quintile in the regression analysis), and urban-rural residence (urban vs. rural). In the random effects models, we also controlled for gender (male vs. female), years of formal schooling (continuously measured), and social engagement. Social engagement was dichotomously measured by whether or not the respondent participated in playing cards, mahjong, or other games or attended religious

services in the past 3 months. This question was only asked in 2010, so we assumed no change in social engagement from 2010 to 2014. These variables are potential confounders as they are all associated with living arrangements and also likely have causal effects on health (Mechanic & Tanner, 2007; Shaw, Fors, Fritzell, Lennartsoon, & Agahi, 2018). In addition, we explored the interaction effects between living alone and age, gender, marital status, social engagement, and income.

Statistical analyses

Factor principal component analysis was conducted to examine the latent factor structure and internal reliability of the scale of the depressive symptoms. This instrument was originally developed in the U.S. (Radloff, 1991) and has been validated for Chinese adolescents (Z. Chen et al., 2009) but not yet for older adults in China. T-tests or chi-square tests were performed to examine whether those living alone and those not-living-alone differed in either the outcomes or predictors.

Fixed-effects and random-effects linear regression modeling was performed to test our hypotheses on the implications of living alone for cognitive and psychological health. The fixed-effects model has the advantage of overcoming potential biases caused by person-specific unmeasured personal characteristics that may affect both living arrangement or marriage and cognitive and psychological health outcomes. In other words, by applying the fixed-effects model, we are able to control for all invariant unobserved characteristics—for example, personality traits, selfishness or altruism levels, and communication skills. That said, using fixed-effects modeling as the "default" for panel data has been challenged (Bell & Jones, 2015) due to the shortcomings of fixed-effects modeling and the advantages of random-effects modeling. To

make up for the shortcomings of fixed-effects modeling and for a comparison, we also ran random-effects models.

Results

Table 1 presents the descriptive statistics of the sample from the 2010 and 2014 waves of CFPS. In 2010, 93.0% of the participants lived with others and 7.0% lived alone. In 2014, 91.1% participants lived with others and 8.9% lived alone. In 2010, the average word score was higher among those living with others, who on average recognized 12.5 (SD = 10.6) out of the maximum 34 words, compared to 9.8 (SD = 10.6) for those living alone. In terms of the math scores ranging from 0 to 24, participants living with others had a higher mean math score (mean = 7.4; SD = 6.3) than those living alone (mean = 5.7; SD = 5.9). As to the levels of depressive symptoms ranging from 0 to 30, those living with others had lower levels of depressive symptoms (mean = 9.1; SD = 4.1) than those living alone (mean = 10.3; SD = 4.9). These patterns remained the same in 2014. Across the 4 years, the average word and math scores declined and the mean levels of depressive symptoms increased in both groups. These unadjusted group differences across the three health outcomes are statistically significant in both 2010 and 2014. Also significant were group differences in age, gender, marital status, and education. Compared to those living with others, participants who lived alone were generally older, and more likely to be female, unmarried, and have years of formal schooling. The two groups did not differ in social engagement, net family income per capita, or urban-rural residence.

[Insert Table 1 about here]

Table 2 presents the results from fixed-effect regression modeling. Model 1 shows the main effects of living alone for all three outcomes controlling for age, marital status, net annual family income per capita, and urban-rural residence. Models 2 to 4 respectively add the

interaction effects of living alone with age, marital status and family income to Model 1. Interaction effects with gender and social engagement cannot be estimated in fixed-effects models because they are time-invariant. According to the fixed-effects regression results, living alone is not related to word or math scores, but is a significant and positive correlate of depressive symptoms, corresponding to about half greater depressive symptom ($p < 0.01$; Model 1 in Table 2 for depressive symptoms) compared to those living with others. Furthermore, a significant interaction effect of living alone with marital status was detected, suggesting living alone is only detrimental to psychological health among unmarried individuals. Figure 1 graphs this interaction plot. The adjusted predicted depressive symptoms are generally greater among the unmarried than among the married, with the living alone penalty being particularly large for the unmarried.

[Insert Table 2 and Figure 1 about here]

Table 3 presents the results from random-effect regression modeling for word scores, math scores and depressive symptoms. Model 1 shows the adjusted main effects of living alone for all three outcomes after controlling for age, gender, marital status, years of schooling, social engagement, annual family income per capita, and urban-rural residence. Model 2 adds the interaction effect of living alone with gender to Model 1, and Model 3 adds the interaction effect with social engagement to Model 1. For word scores (see Table 3a), neither the main effect nor any of the interaction effects is significant, consistent with the results from the fixed-effects modeling.

[Insert Table 3a about here]

For math scores (see Table 3b), the main effect of living alone is not significant, whereas the living alone by gender interaction effect is significant such that living alone is detrimental to

math scores for men but not for women (coefficient of living alone × male = -0.46; $p < 0.05$; Model 2 in Table 3b). No other interaction effects are found. This is not inconsistent with the results from fixed-effects modeling in that the interaction effect of living alone with gender can only be estimated in random-effects modeling. Figure 2 plots this interaction effect. The living alone penalty on math scores is substantial only among the male.

[Insert Table 3b and Figure 2 about here]

The results on depressive symptoms from random-effects modeling are shown in Table 3c, and are also consistent with the findings from the fixed-effects modeling. That is, those living alone report higher levels of depressive symptoms than those living with others (coefficient = 0.658; $p < 0.001$; Model 1 in Table 3c). Neither of the two interaction effects examined in Model 2 or Model 3 is significant.

[Insert Table 3c about here]

Several side findings are also noteworthy. According to the results from fixed-effects modeling, the older people were, the lower cognitive abilities they manifested in the word and math test scores. Young elders aged 60 to 79 exhibited the highest levels of depressive symptoms, compared to the middle aged and the oldest old. In addition, being married and having higher income corresponded to better psychological health. The results from random-effects modeling show that male gender, formal schooling and active social engagement were beneficial factors for all three outcomes consistently across all the models.

Discussion

The link between living arrangement and health has been extensively studied (Hakansson et al., 2009; Stern, 2012). However, research on the health implications of living alone is limited. Evidence is particularly lacking on the cognitive health implications of living alone and the

moderating effects of socio-demographic characteristics in the Chinese population. In addition, the majority of publications on this topic have been cross-sectional and only included older adults. Although less studied than the two ends of the age spectrum in the health disparity literature, middle age is likely a turning point for age-related health declines (Singh-Manoux et al., 2012). More research is needed to investigate social determinants of health among the middle-aged.

Analyzing the 2010 and 2014 waves of data from a large scale, nationwide longitudinal survey (CFPS) in China, we found complex health implications of living alone among middle-aged and older Chinese age 50 or above. The effect of living alone on cognitive health was only significant among men and when cognitive health was measured by math scores. This finding lends some support to our expectation that living alone should take a greater toll on men than on women. However, no gender moderation effect was found for word scores or depressive symptoms, suggesting that the role of gender in the health implications of living alone is not uniform, but dependent on specific outcomes and study populations.

Whether living alone is a positive or negative factor for psychological health depends on marital status. Among the married, those living alone and those living with others did not exhibit any difference in psychological health. Based on previous evidence on the health implications of living alone, we formulated our primary hypothesis that living with others would be more beneficial than living alone. The results on the non-significant health effects of living alone among the married are not consistent with this hypothesis but not surprising given the established health benefits associated with marriage (J. H. Chen, Waite, & Lauderdale, 2015; Hughes & Waite, 2009; Waite, 1995; Wong & Waite, 2015). That said, individuals who are married but living alone rather than with their spouses constitute a unique sociodemographic group,

essentially in "Living Apart Together" (LAT) relationships. The present study is among the first to report on this group, which is under-researched in the health disparity literature.

In western countries, the LAT phenomenon is gaining visibility (Strohm, Seltzer, Cochran, & Mays, 2009). The term refers to an intimate, committed relationship that exists between two partners without a shared residence (Strohm et al., 2009). Some LAT couples are formally married. A recent study found that formally married LAT couples accounted for around 5% of adults in Norway, Belgium, France, Germany, Hungary, Romania, Bulgaria, and Lithuania, 12% in Russia, and 48% in Georgia (Liefbroer, Poortman, & Seltzer, 2015). A tentative conclusion from this study was that LAT is more often a stage in the union formation process than an alternative to marriage and cohabitation, as most people in LAT unions intend to live together but are apart for practical reasons. The authors also report that older people and divorced or widowed persons are more likely to choose LAT to maintain independence, suggesting an age- and marriage-dependent picture of whether or not individuals choose LAT as a conscious, long-term strategy and view LAT as substituting for marriage and cohabitation.

In our study, the prevalence of married LAT relationships is 19.1%, which means nearly one out of five people living alone in our sample was married; this figure is surprisingly high, given that traditional Chinese culture strongly endorses family life. As to why people enter LAT relationships in China, a recent qualitative study reported diverse reasons for getting into this type of "unusual union," including reasons similar to those reported in western studies, as well as unique reasons such as Chinese "study mothers" accompanying and taking care of their children during their courses of study (Qiu, 2017). Regardless of motivations, in this sample, the participants who were living alone and married had similar cognitive and psychological health status to those living with others and fared better than those living alone and not married. A U.S.

based study reported that people in LAT relationships perceived similar amounts of emotional support from their partners but less instrumental support than cohabiters perceived (Strohm et al., 2009). If this is also the case in China, then it can be postulated that the amounts of emotional support married couples provide for each other do not differ according to whether or not they share the same household. Clearly, more research needs to be done to better understand the prevalence of LAT, the reasons for LAT, the quality of LAT relationships vis-à-vis those married & living together, and the implications of LAT for health and well-being in China.

Other than the moderating effects of gender and marital status, we also examined age, social engagement, and family income as potential moderators. None of these moderating effects were significant in the analysis. Among these three factors, social engagement is the most amenable. We were hoping social engagement could mitigate the detrimental effects of living alone among the currently unmarried but our findings did not support this hypothesis. One caveat is that our social engagement measure was crude, only tapping whether the individual was actively engaged in playing cards, mahjong, or other games or attended religious services in the past three months and no frequency information was tapped. There are other formal or informal ways of engaging socially, which can be captured by more comprehensive measures of social engagement (Trinh & Wen, 2016).

In any event, regardless of living arrangement, the significant benefits of social engagement in all the models for all three outcomes observed in this study are impressive and consistent with previous literature highlighting the salubrious effects of socio-relational resources (Barrett, 1999; Fukunaga et al., 2012; Holtzman et al., 2004; Krueger et al., 2009; MacNeill et al., 2002; Zunzunegui et al., 2003). A key implication of this finding is that government programs or interventions should encourage greater social engagement and promote

social support among the middle-aged and elderly. Given the detrimental effects of living alone on psychological health among the unmarried and cognitive health among men, solo-living middle-aged and older unmarried men should be particularly prioritized for health intervention.

Using data from a nationwide prospective cohort survey recently collected in China, our study has made novel contributions to the living arrangement and health literature by examining the implications of living alone for cognitive and psychological health, testing the moderating effects of five socio-demographic characteristics, and including the middle-aged in the analysis. A major limitation of this study is that only two repeated measures were used due to the incompatibility of the questionnaire designs. Longer-term effects could not be studied in this design. The main and interaction effects may be different with longer follow-up time. Although prospective cohort study design is the most rigorous among observational studies in terms of reducing bias, no causal inferences should be assumed for the observed associations.

In conclusion, this study confirms that there are no benefits but some harmful effects associated with living alone for middle-aged and older adults in China and that marital status plays a salient role in differentiating the impact of living-alone on psychological health. The study also reports more detrimental effects of living alone on cognitive health for men than for women. More research is warranted to further study these issues and other health outcomes, explore the mechanisms through which living alone may be linked to health, and examine additional moderating effects. Evidence thus produced can be more informative for policy and program development to effectively enhance population health. To meet the challenges of an aging society, a key public health goal is to establish age-friendly and health-promoting physical and social infrastructures to increase the proportions of people who live into their 70s, 80s, and 90s in good health.

References

Alzheimer's Association, & Centers for Disease Control and Prevention. (2013). The Healthy Brian Initiative: The public health map for state and national leaderships, 2013-2018. Chicago, IL: Alzheimer's Association.

Barnes, D. E., Tager, I. B., Satariano, W. A., & Yaffe, K. (2004). The relationship between literacy and cognition in well-educated elders. *J Gerontol A Biol Sci Med Sci, 59*(4), 390-395.

Barrett, A. E. (1999). Social support and life satisfaction among the never married - Examining the effects of age. *Research on Aging, 21*(1), 46-72. doi: 10.1177/0164027599211003

Bassuk, S. S., Glass, T. A., & Berkman, L. F. (1999). Social disengagement and incident cognitive decline in community-dwelling elderly persons. *Ann Intern Med, 131*(3), 165-173.

Bell, Andrew, & Jones, Kelvyn. (2015). Explaining fixed effects: Random effects modeling of time-series cross-sectional and panel data. *Political Science Research and Methods, 3*(1), 133-153.

Berkman, L. F. (2000). Which influences cognitive function: living alone or being alone? *Lancet, 355*(9212), 1291-1292. doi: 10.1016/s0140-6736(00)02107-3

Cattell, Raymond B. (1987). *Intelligence: Its Structure, Growth, and Action*. Amsterdam: North-Holland.

Chen, J. H., Waite, L. J., & Lauderdale, D. S. (2015). Marriage, Relationship Quality, and Sleep among U.S. Older Adults. *J Health Soc Behav, 56*(3), 356-377. doi: 10.1177/0022146515594631

Chen, Y., & While, A. E. (2019). Older people living alone in Shanghai: A questionnaire survey of their life experience. *Health Soc Care Community, 27*(1), 260-269. doi: 10.1111/hsc.12648

Chen, Zhiyan, Yang, Xiaodong, & Li, Xinying. (2009). Psychometric features of CES-D in Chinese adolescents. *Chinese Journal of Clinical Psychology, 17*(4), 443-445.

Cheng, S. T., Fung, H. H., & Chan, A. C. (2008). Living status and psychological well-being: social comparison as a moderator in later life. *Aging Ment Health, 12*(5), 654-661. doi: 10.1080/13607860802343241

Cheung, A. K. L., & Yeung, W. J. J. (2015). Temporal-spatial patterns of one-person households in China, 1982-2005. *Demographic Research, 32*, 1209-1238.

Chokshi, D. A. (2018). Income, Poverty, and Health Inequality. *Jama, 319*(13), 1312-1313. doi: 10.1001/jama.2018.2521

Chou, K. L., Ho, A. H., & Chi, I. (2006). Living alone and depression in Chinese older adults. *Aging Ment Health, 10*(6), 583-591. doi: 10.1080/13607860600641150

Christakis, Nicholas, & Fowler, James. (2009). *Connected: The Surprising Power of Our Social Networks and How They Shape Our Lives*. New York, NY: Little, Brown and Company.

Conroy, R. M., Golden, J., Jeffares, I., O'Neill, D., & McGee, H. (2010). Boredom-proneness, loneliness, social engagement and depression and their association with cognitive function in older people: a population study. *Psychol Health Med, 15*(4), 463-473. doi: 10.1080/13548506.2010.487103

Dykiert, D., Der, G., Starr, J. M., & Deary, I. J. (2016). Why is Mini-Mental state examination performance correlated with estimated premorbid cognitive ability? *Psychol Med, 46*(12), 2647-2654. doi: 10.1017/s0033291716001045

Evans, I. E. M., Llewellyn, D. J., Matthews, F. E., Woods, R. T., Brayne, C., Clare, L., & Team, C. FAS-Wales Res. (2019). Living alone and cognitive function in later life. *Archives of Gerontology and Geriatrics, 81*, 222-233. doi: 10.1016/j.archger.2018.12.014

Ferrari, A. J., Charlson, F. J., Norman, R. E., Patten, S. B., Freedman, G., Murray, C. J., . . . Whiteford, H. A. (2013). Burden of depressive disorders by country, sex, age, and year: findings from the global burden of disease study 2010. *PLoS Med, 10*(11), e1001547. doi: 10.1371/journal.pmed.1001547

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res, 12*(3), 189-198.

Fukunaga, R., Abe, Y., Nakagawa, Y., Koyama, A., Fujise, N., & Ikeda, M. (2012). Living alone is associated with depression among the elderly in a rural community in Japan. *Psychogeriatrics, 12*(3), 179-185. doi: 10.1111/j.1479-8301.2012.00402.x

Gardner, Harold H., & Gardner, B. Delworth. (2012). Health as human capital: Theory and implications. http://www.hcmsgroup.com/wp-content/uploads/2012/05/WP01-HHC-Theory-and-Implications-2012-01-161.pdf

Glick, Paul C. (1994). Living alone during middle adulthood. *Sociological Perspectives, 37*(3), 445-457.

Gow, A. J., Corley, J., Starr, J. M., & Deary, I. J. (2013). Which social network or support factors are associated with cognitive abilities in old age? *Gerontology, 59*(5), 454-463. doi: 10.1159/000351265

Hakansson, K., Rovio, S., Helkala, E. L., Vilska, A. R., Winblad, B., Soininen, H., . . . Kivipelto, M. (2009). Association between mid-life marital status and cognitive function in later life: population based cohort study. *Bmj, 339*, b2462. doi: 10.1136/bmj.b2462

Heinik, J., Solomesh, I., & Berkman, P. (2004). Correlation between the CAMCOG, the MMSE, and three clock drawing tests in a specialized outpatient psychogeriatric service. *Arch Gerontol Geriatr, 38*(1), 77-84.

Heshmati, Almas. (2016). *The economics of healthy aging in China*. (9713).

Holtzman, R. E., Rebok, G. W., Saczynski, J. S., Kouzis, A. C., Wilcox Doyle, K., & Eaton, W. W. (2004). Social network characteristics and cognition in middle-aged and older adults. *J Gerontol B Psychol Sci Soc Sci, 59*(6), P278-284.

Huang, G., Xie, Y., & Xu, H. (2015). Cognitive ability: Social correlates and consequences in contemporary China. *Chin Sociol Rev, 47*(4), 287-313. doi: 10.1080/21620555.2015.1032161

Hughes, M. E., & Waite, L. J. (2002). Health in household context: living arrangements and health in late middle age. *J Health Soc Behav, 43*(1), 1-21.

Hughes, M. E., & Waite, L. J. (2009). Marital biography and health at mid-life. *J Health Soc Behav, 50*(3), 344-358. doi: 10.1177/002214650905000307

Jeon, G. S., Choi, K., & Cho, S. I. (2017). Impact of living alone on depressive symptoms in older Korean widows. *Int J Environ Res Public Health, 14*(10).

Jeon, G. S., Jang, S. N., Rhee, S. J., Kawachi, I., & Cho, S. I. (2007). Gender differences in correlates of mental health among elderly Koreans. *J Gerontol B Psychol Sci Soc Sci, 62*(5), S323-329.

Josefsson, M., de Luna, X., Daniels, M. J., & Nyberg, L. (2016). Causal inference with longitudinal outcomes and non-ignorable drop-out: Estimating the effect of living alone

on cognitive decline. *J R Stat Soc Ser C Appl Stat, 65*(1), 131-144. doi: 10.1111/rssc.12110
Jung, Y. M., & Kim, J. H. (2004). [Comparison of cognitive levels, nutritional status, depression in the elderly according to living situations]. *Taehan Kanho Hakhoe Chi, 34*(3), 495-503.
Kim, Y. J. (2009). Comparison of Health Habits, Perceived Stress, Depression, and Suicidal Thinking by Gender between Elders Living Alone and Those Living with Others. . *Jounral of Korean Academy of Fundamentals of Nursing, 16*(4), 333-344.
Klinenberg, Eric. (2012). *Going Solo: The Extraordinary Rise and Surprising Appeal of Living Alone*. New York, NY: The Penguin Group.
Knoema. (2015). China-Total population aged 50 and over years. Retrieved March 18, 2018, from https://knoema.com/atlas/China/topics/Demographics/Age/Population-aged-50-years
Krueger, K. R., Wilson, R. S., Kamenetsky, J. M., Barnes, L. L., Bienias, J. L., & Bennett, D. A. (2009). Social engagement and cognitive function in old age. *Exp Aging Res, 35*(1), 45-60. doi: 10.1080/03610730802545028
Lee, S., & Hong, G. R. (2016). Predictors of depression among community-dwelling older women living alone in Korea. *Arch Psychiatr Nurs, 30*(5), 513-520. doi: 10.1016/j.apnu.2016.05.002
Li, D., Zhang, D. J., Shao, J. J., Qi, X. D., & Tian, L. (2014). A meta-analysis of the prevalence of depressive symptoms in Chinese older adults. *Arch Gerontol Geriatr, 58*(1), 1-9. doi: 10.1016/j.archger.2013.07.016
Liefbroer, A. C., Poortman, A. R., & Seltzer, J. A. (2015). Why do intimate partners live apart? Evidence on LAT relationships across Europe. *Demogr Res, 32*, 251-286. doi: 10.4054/DemRes.2015.32.8
MacNeill, Susan E., Bank, Adam L., & Lichtenberg, Peter A. (2002). Cognition and perceived social support among live-alone urban elders. *Journal of Applied Gerontology, 21*(4), 437-451.
Mazzuco, S., Meggiolaro, S., Ongaro, F., & Toffolutti, V. (2016). Living arrangmeent and cognitive decline in Europe. *Ageing and Society, 37*(1), 1-23.
McLaren, S. (2016). The relationship between living alone and depressive symptoms among older gay men: the moderating role of sense of belonging with gay friends. *Int Psychogeriatr, 28*(11), 1895-1901.
Mechanic, D., & Tanner, J. (2007). Vulnerable people, groups, and populations: societal view. *Health Aff (Millwood), 26*(5), 1220-1230. doi: 10.1377/hlthaff.26.5.1220
Michael, Y. L., Berkman, L. F., Colditz, G. A., & Kawachi, I. (2001). Living arrangements, social integration, and change in functional health status. *Am J Epidemiol, 153*(2), 123-131.
Molloy, D. W., Alemayehu, E., & Roberts, R. (1991). Reliability of a Standardized Mini-Mental State Examination compared with the traditional Mini-Mental State Examination. *Am J Psychiatry, 148*(1), 102-105. doi: 10.1176/ajp.148.1.102
Mortimer, J. A., Ding, D., Borenstein, A. R., DeCarli, C., Guo, Q., Wu, Y., . . . Chu, S. (2012). Changes in brain volume and cognition in a randomized trial of exercise and social interaction in a community-based sample of non-demented Chinese elders. *J Alzheimers Dis, 30*(4), 757-766. doi: 10.3233/jad-2012-120079

Mouodi, S., Bijani, A., Hosseini, S. R., & Hajian-Tilaki, K. (2016). Gender differences in the health status of elderly living alone compared to those who are not alone: Evidence of the AHAP study, North of Iran. *Caspian J Intern Med, 7*(2), 126-132.

Muennig, P. (2008). Health selection vs. causation in the income gradient: what can we learn from graphical trends? *J Health Care Poor Underserved, 19*(2), 574-579. doi: 10.1353/hpu.0.0018

Ng, Ka-Man, Lee, tatia MC, & Chi, Iris. (2004). Relationship between living arrangements and the psychological well-being of older people in Hong Kong. *Australasian Journal on Ageing, 23*(4), 167–171.

Oh, E. H., Kim, M. D., & Hong, S. C. (2009). The effect of the traditional living arrangement, anpakkori, on depressive symptoms in elderly people residing on jeju island. *Psychiatry Investig, 6*(3), 131-140. doi: 10.4306/pi.2009.6.3.131

Osborn, D. P., Fletcher, A. E., Smeeth, L., Stirling, S., Bulpitt, C. J., Breeze, E., . . . Tulloch, A. (2003). Factors associated with depression in a representative sample of 14 217 people aged 75 and over in the United Kingdom: results from the MRC trial of assessment and management of older people in the community. *Int J Geriatr Psychiatry, 18*(7), 623-630. doi: 10.1002/gps.896

Park, N. S., Jang, Y., Lee, B. S., & Chiriboga, D. A. (2017). The relation between living alone and depressive symptoms in older Korean Americans: do feelings of loneliness mediate? *Aging Ment Health, 21*(3), 304-312.

Pfeiffer, E. (1975). A short portable mental status questionnaire for the assessment of organic brain deficit in elderly patients. *J Am Geriatr Soc, 23*(10), 433-441.

Pulkki-Raback, L., Kivimaki, M., Ahola, K., Joutsenniemi, K., Elovainio, M., Rossi, H., . . . Virtanen, M. (2012). Living alone and antidepressant medication use: a prospective study in a working-age population. *BMC Public Health, 12*, 236.

Qiu, Shuang. (2017). Chinese Study Mothers" in living-apart-together relationships *Family Focus: Families with Differences*: National Council on Family Relations (NCFR).

Radloff, L. S. (1991). THE USE OF THE CENTER FOR EPIDEMIOLOGIC STUDIES DEPRESSION SCALE IN ADOLESCENTS AND YOUNG-ADULTS. *Journal of Youth and Adolescence, 20*(2), 149-166. doi: 10.1007/bf01537606

Reissman, C.K. (1990). *Divorce Talk: Women and Men Make Sense of Personal Relationships*. New Brunswick, NJ: Rutgers University Press.

Ren, L., Zheng, Y., Wu, L., Gu, Y., He, Y., Jiang, B., . . . Li, J. (2018). Investigation of the prevalence of Cognitive Impairment and its risk factors within the elderly population in Shanghai, China. *Sci Rep, 8*(1), 3575. doi: 10.1038/s41598-018-21983-w

Ren, Qiang, & Treiman, Donald J. (2015). Living arrangements of the elderly in China and consequences for their emotional well-being. *Chinese Sociological Review, 47*(3), 255-286.

Roccaforte, W. H., Burke, W. J., Bayer, B. L., & Wengel, S. P. (1994). Reliability and validity of the Short Portable Mental Status Questionnaire administered by telephone. *J Geriatr Psychiatry Neurol, 7*(1), 33-38.

Roth, M., Tym, E., Mountjoy, C. Q., Huppert, F. A., Hendrie, H., Verma, S., & Goddard, R. (1986). CAMDEX: A Standardised Instrument for the Diagnosis of Mental Disorder in the Elderly with Special Reference to the Early Detection of Dementia. *The British Journal of Psychiatry, 149*(6), 698-709.

Russell, D., & Taylor, J. (2009). Living alone and depressive symptoms: the influence of gender, physical disability, and social support among Hispanic and non-Hispanic older adults. *J Gerontol B Psychol Sci Soc Sci, 64*(1), 95-104.
Schieman, Scott. (1999). Age and Anger. *Journal of Health and Social Behavior, 40*(3), 273-289.
Shaw, B. A., Fors, S., Fritzell, J., Lennartsoon, C., & Agahi, N. (2018). Who lives alone during old age? Trends in the social and functional disadvantages of Sweden's solitary living older adults. *Research on Aging, 40*(9), 815-838. doi: 10.1177/0164027517747120
Singh-Manoux, A., Kivimaki, M., Glymour, M. M., Elbaz, A., Berr, C., Ebmeier, K. P., . . . Dugravot, A. (2012). Timing of onset of cognitive decline: results from Whitehall II prospective cohort study. *Bmj, 344*, d7622. doi: 10.1136/bmj.d7622
Smith, J. P., Strauss, J., & Zhao, Y. (2014). Healthy Aging in China. *J Econ Ageing, 4*, 37-43. doi: 10.1016/j.jeoa.2014.08.006
Stepler, Renee. (2016). Well-being of older adults living alone. Retrieved February 8, 2019, from http://www.pewsocialtrends.org/2016/02/18/3-well-being-of-older-adults-living-alone/
Stern, Y. (2012). Cognitive reserve in ageing and Alzheimer's disease. *Lancet Neurol, 11*(11), 1006-1012. doi: 10.1016/s1474-4422(12)70191-6
Strohm, C. Q., Seltzer, J. A., Cochran, S. D., & Mays, V. M. (2009). "Living Apart Together" relationships in the United States. *Demogr Res, 21*, 177-214.
Sun, Xiaoyan, Yu, Canqing, & Li, Liming. (2018). Prevalence and influencing factor of depression aong empty-nest elderly: A systematic review. *Chinese Journal of Public Health, 34*(1), 153-156.
Trinh, H. N., & Wen, M. (2016). Social engagement and use of hypertensie medication among adults in China. *Journal of Biosocial Science, 48*(6), 806-819. doi: 10.1017/s0021932015000425
Turner, R. J., & Marino, F. (1994). Social support and social structure: a descriptive epidemiology. *J Health Soc Behav, 35*(3), 193-212.
van Gelder, B. M., Tijhuis, M., Kalmijn, S., Giampaoli, S., Nissinen, A., & Kromhout, D. (2006). Marital status and living situation during a 5-year period are associated with a subsequent 10-year cognitive decline in older men: the FINE Study. *J Gerontol B Psychol Sci Soc Sci, 61*(4), P213-219.
Waite, L. J. (1995). Does marriage matter? *Demography, 32*(4), 483-507.
Wen, M. (2017). Social Capital and Adolescent Substance Use: The Role of Family, School, and Neighborhood Contexts. *J Res Adolesc, 27*(2), 362-378. doi: 10.1111/jora.12299
Whitney, K. A., Maoz, O., Hook, J. N., Steiner, A. R., & Bieliauskas, L. A. (2007). IQ and scores on the Mini-Mental State Examination (MMSE): controlling for effort and education among geriatric inpatients. *Neuropsychol Dev Cogn B Aging Neuropsychol Cogn, 14*(5), 545-552. doi: 10.1080/13825580600850934
Wong, J. S., & Waite, L. J. (2015). Marriage, Social Networks, and Health at Older Ages. *J Popul Ageing, 8*(1-2), 7-25. doi: 10.1007/s12062-014-9110-y
Woodford, H.J., & George, J. (2007). Cognitive assessment in the elderly: a review of clinical methods. *QJM: An International Journal of Medicine, 100*(8), 469-484.
Xie, Y., & Hu, J. W. (2014). An Introduction to the China Family Panel Studies (CFPS). *Chinese Sociological Review, 47*(1), 3-29. doi: 10.2753/csa2162-0555470101

Xu, Hongwei, & Yu, Xie. (2015). Number series test in the 2012 Wave of China Family Panel Studies *Technical Report CFPS-31*. Beijing: Institute for Social Science Survey, Peking University.

Yaffe, K., Fiocco, A. J., Lindquist, K., Vittinghoff, E., Simonsick, E. M., Newman, A. B., . . . Harris, T. B. (2009). Predictors of maintaining cognitive function in older adults: the Health ABC study. *Neurology, 72*(23), 2029-2035. doi: 10.1212/WNL.0b013e3181a92c36

Yeung, W. Jean, & Cheung, Adam Ka-Lok. (2015). Living alone: One-person households in Asia. *Demographic Research, 32*, 1099-1112.

Yeung, W. Jean, Feng, Qishui, Wang, Zhenglian, & Zeng, Yi. (2016). *Living alone in China: Projection of one-person household, 2010 to 2050*. Paper presented at the Population Association of America Annual Meeting, Washington, D.C.

Yu, C. Y., Hou, S. I., & Miller, J. (2018). Health for Older Adults: The Role of Social Capital and Leisure-Time Physical Activity by Living Arrangements. *Journal of Physical Activity & Health, 15*(2), 150-158. doi: 10.1123/jpah.2017-0006

Zebhauser, A., Baumert, J., Emeny, R. T., Ronel, J., Peters, A., & Ladwig, K. H. (2015). What prevents old people living alone from feeling lonely? Findings from the KORA-Age-study. *Aging Ment Health, 19*(9), 773-780. doi: 10.1080/13607863.2014.977769

Zhong, B. L., Chen, S. L., & Conwell, Y. (2016). Effects of Transient Versus Chronic Loneliness on Cognitive Function in Older Adults: Findings From the Chinese Longitudinal Healthy Longevity Survey. *Am J Geriatr Psychiatry, 24*(5), 389-398. doi: 10.1016/j.jagp.2015.12.009

Zhong, B. L., Chen, S. L., Tu, X., & Conwell, Y. (2017). Loneliness and Cognitive Function in Older Adults: Findings From the Chinese Longitudinal Healthy Longevity Survey. *J Gerontol B Psychol Sci Soc Sci, 72*(1), 120-128. doi: 10.1093/geronb/gbw037

Zhou, Z., Wang, P., & Fang, Y. (2018). Social Engagement and Its Change are Associated with Dementia Risk among Chinese Older Adults: A Longitudinal Study. *Sci Rep, 8*(1), 1551. doi: 10.1038/s41598-017-17879-w

Zunzunegui, M. V., Alvarado, B. E., Del Ser, T., & Otero, A. (2003). Social networks, social integration, and social engagement determine cognitive decline in community-dwelling Spanish older adults. *J Gerontol B Psychol Sci Soc Sci, 58*(2), S93-s100.

Table 1. Descriptive Statistics

	Living with others		Living alone	
	Mean/%	S.D.	Mean/%	S.D.
2010				
Word test***	12.5	10.6	9.8	10.6
Math test***	7.4	6.3	5.7	5.9
Depressive symptoms***	9.1	4.1	10.3	4.9
Age group***				
50-59	53.3%		33.6%	
60-79	45.1%		60.3%	
80+	1.6%		6.1%	
Female gender***	49.4%		57.6%	
Currently not married***	7.6%		80.9%	
Schooling year***	5.2	4.6	4.0	4.6
Social engagement (active)	20.6		20.6	
Net family income per capita (Yuan)	9,444	14,242	9,118	11,074
Urban residence	44.2%		43.6%	
Sample sizes	8,809		660	
2014				
Word test***	11.1	10.6	8.7	10.3
Math test***	6.9	6.3	5.4	6.0
Depressive symptoms***	9.4	4.4	10.5	5.3
Age group***				
50-59	30.5%		19.7%	
60-79	65.3%		65.5%	
80+	4.2%		14.8%	
Female gender*	49.6%		53.4%	
Currently not married***	10.1%		83.4%	
Schooling year***	5.2	4.6	4.2	4.5
Social engagement (active)	20.7%		19.6%	
Net family income per capita (Yuan)	13,126	19,162	13,732	17,098
Urban residence	47.6%		46.3%	
Sample sizes	8,630		839	

Note: *p<0.05; **p<0.01; ***p<0.001

Table 2. Coefficients from Fixed Effect Modeling of Word Scores, Math Scores and Depressive Symptoms

	Word Test Scores				Math Test Scores				Depressive Symptoms			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Living alone	-0.114	-0.326	0.089	-0.614	-0.055	-0.229	-0.104	-0.085	0.504**	0.830**	-0.011	0.486
	(0.329)	(0.505)	(0.521)	(0.528)	(0.142)	(0.217)	(0.225)	(0.227)	(0.222)	(0.340)	(0.351)	(0.356)
Age group (rf.: Age 50-59)												
Age 60-79	-1.259***	-1.279***	-1.260***	-1.264***	-0.396***	-0.410***	-0.395***	-0.396***	0.277**	0.299***	0.279**	0.276**
	(0.166)	(0.169)	(0.166)	(0.166)	(0.072)	(0.073)	(0.072)	(0.072)	(0.112)	(0.114)	(0.112)	(0.112)
Age 80+	-2.778***	-2.619***	-2.782***	-2.788***	-0.664***	-0.593***	-0.663***	-0.665***	0.170	0.240	0.182	0.170
	(0.469)	(0.511)	(0.469)	(0.469)	(0.202)	(0.220)	(0.202)	(0.202)	(0.316)	(0.344)	(0.316)	(0.316)
Unmarried	-0.490	-0.496	-0.423	-0.487	-0.142	-0.152	-0.159	-0.142	0.458*	0.489*	0.287	0.458*
	(0.386)	(0.388)	(0.409)	(0.386)	(0.166)	(0.167)	(0.176)	(0.166)	(0.260)	(0.261)	(0.275)	(0.260)
Family income quintile	0.038	0.038	0.038	0.029	0.013	0.013	0.013	0.013	-0.072***	-0.071***	-0.0715***	-0.072***
	(0.027)	(0.027)	(0.027)	(0.028)	(0.012)	(0.012)	(0.012)	(0.012)	(0.018)	(0.018)	(0.018)	(0.019)
Urban vs rural residence	-0.269	-0.278	-0.272	-0.268	-0.256	-0.261	-0.255	-0.256	0.148	0.150	0.155	0.148
	(0.369)	(0.369)	(0.369)	(0.369)	(0.159)	(0.159)	(0.159)	(0.159)	(0.249)	(0.249)	(0.249)	(0.249)
Living alone × Age 60-79		0.400				0.301				-0.472		
		(0.581)				(0.250)				(0.391)		
Living alone × Age 80+		-0.381				-0.078				-0.662		
		(0.999)				(0.430)				(0.673)		
Living alone × Unmarried			-0.331				0.081				0.840*	
			(0.661)				(0.285)				(0.445)	
Living alone × Income				0.093				0.006				0.003
				(0.077)				(0.033)				(0.052)
Constant	12.41***	12.42***	12.41***	12.46***	7.343***	7.354***	7.343***	7.346***	9.398***	9.379***	9.403***	9.400***
	(0.248)	(0.249)	(0.248)	(0.252)	(0.107)	(0.107)	(0.107)	(0.109)	(0.167)	(0.168)	(0.167)	(0.170)

Note: *p<0.05; **p<0.01; ***p<0.001; Number of observations=18,938; Number of respondents=9,469; Standard errors in parentheses.

Figure 1. Interaction Plot of Living Arrangement and Marital Status on Depressive Symptoms

(based on fixed-effects regression results)

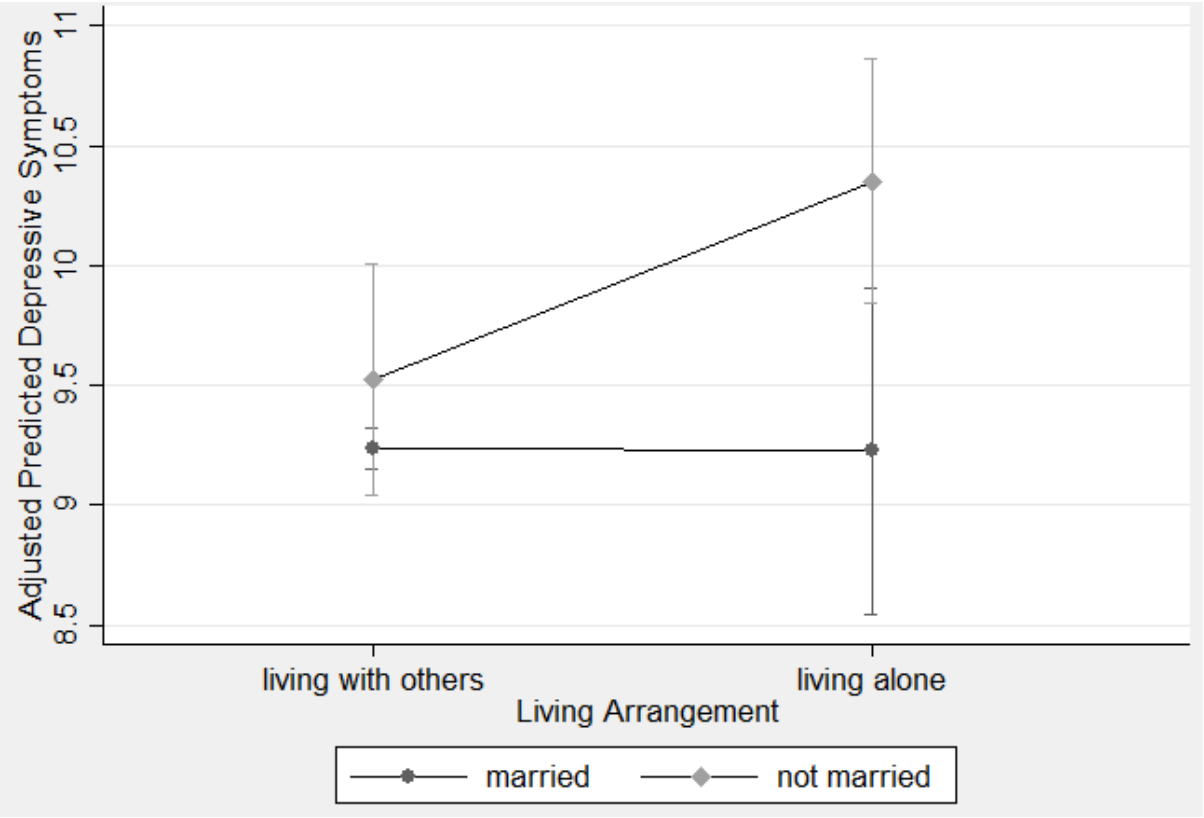

Table 3a. Coefficients from Random Effect Modeling of Word Test Scores

	Model 1	Model 2	Model 3
Living arrangements (rf.: Living with others)			
Living alone	-0.224	0.048	-0.149
	(0.226)	(0.283)	(0.244)
Age group (rf.: Age 50-59)			
Age 60-79	-0.196*	-0.195*	-0.196*
	(0.108)	(0.108)	(0.108)
Age 80+	-1.604***	-1.614***	-1.602***
	(0.299)	(0.299)	(0.299)
Male vs female	2.301***	2.351***	2.302***
	(0.124)	(0.128)	(0.124)
Not married vs married	-0.489**	-0.483**	-0.487**
	(0.190)	(0.190)	(0.190)
Years of formal schooling	1.525***	1.525***	1.525***
	(0.014)	(0.014)	(0.014)
Social engagement (rf.: not active)			
Active	1.125***	1.125***	1.155***
	(0.146)	(0.146)	(0.151)
Annual family income per capita quintile	0.264***	0.265***	0.264***
	(0.019)	(0.019)	(0.019)
Urban vs rural residence	1.398***	1.394***	1.398***
	(0.123)	(0.124)	(0.123)
Living alone × Male		-0.616	
		(0.387)	
Living alone × Active social engagement			-0.390
			(0.485)
Constant	0.570***	0.546***	0.564***
	(0.150)	(0.151)	(0.150)

Note: Number of observations=18,938; Number of respondents=9,469; *p<0.05; **p<0.01; ***p<0.001; Standard errors in parentheses

Table 3b. Coefficients from Random Effect Modeling of Math Test Scores

	Model 1	Model 2	Model 3
Living arrangements (rf.: Living with others)			
Living alone	-0.134	0.066	-0.098
	(0.103)	(0.129)	(0.111)
Age group (rf.: Age 50-59)			
Age 60-79	-0.574***	-0.574***	-0.574***
	(0.049)	(0.049)	(0.049)
Age 80+	-0.922***	-0.927***	-0.921***
	(0.137)	(0.137)	(0.137)
Male vs female	0.509***	0.545***	0.509***
	(0.059)	(0.061)	(0.059)
Not married vs married	-0.129	-0.125	-0.128
	(0.088)	(0.088)	(0.088)
Years of formal schooling	1.096***	1.095***	1.096***
	(0.007)	(0.007)	(0.007)
Social engagement (rf.: not active)			
Active	0.387***	0.387***	0.402***
	(0.070)	(0.070)	(0.072)
Family income quintile	0.086***	0.087***	0.086***
	(0.008)	(0.008)	(0.008)
Urban vs rural residence	0.422***	0.419***	0.422***
	(0.058)	(0.058)	(0.058)
Living alone × Male		-0.455**	
		(0.177)	
Living alone × Active			-0.190
Constant	0.796***	0.778***	0.793***
	(0.070)	(0.071)	(0.070)

Note: Number of observations=18,938; Number of respondents=9,469; *p<0.05; **p<0.01; ***p<0.001; Standard errors in parentheses.

Figure 2. Interaction Plot of Living Arrangement and Gender on Math Scores with 95% CIs
(based on random-effects regression results)

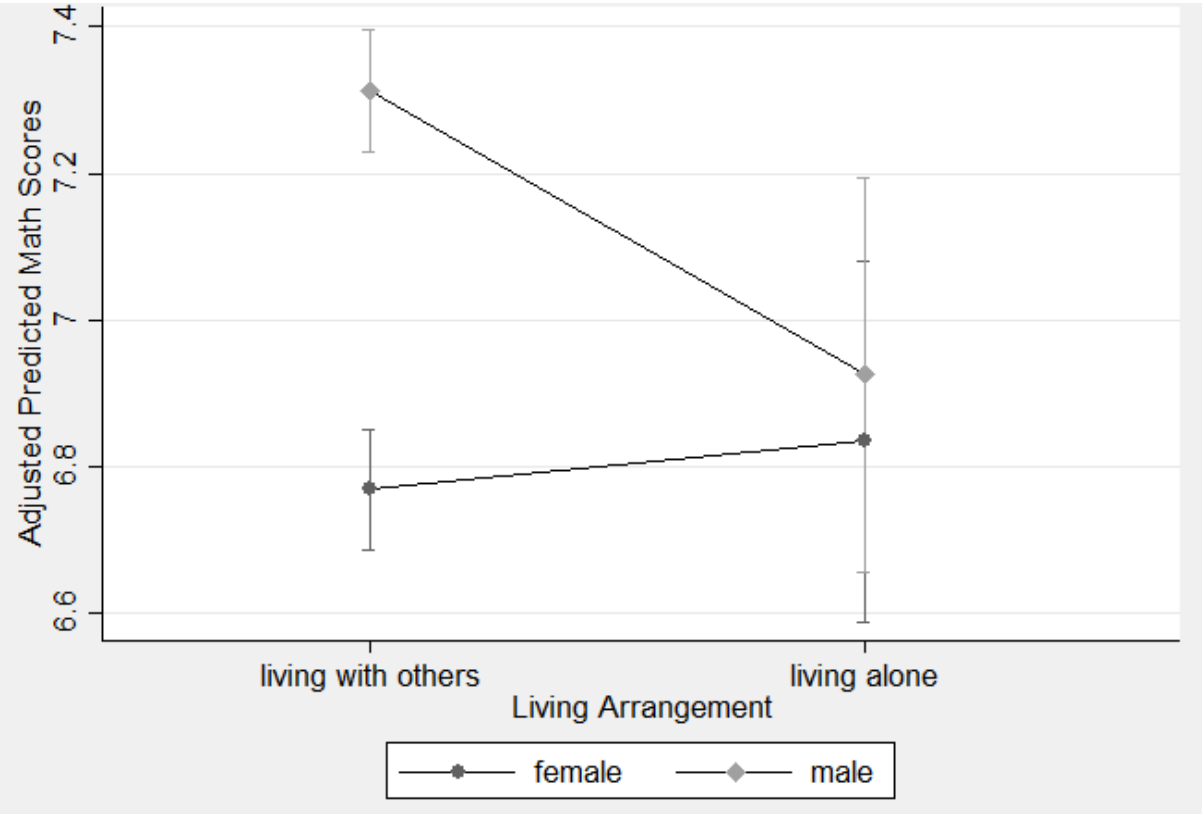

Table 3c. Coefficients from Random Effect Modeling of Depressive Symptoms

	Model 1	Model 2	Model 3
Living arrangements (rf.: Living with others)			
Living alone	0.658***	0.721***	0.731***
	(0.141)	(0.176)	(0.152)
Age group (rf.: Age 50-59)			
Age 60-79	-0.059	-0.059	-0.059
	(0.067)	(0.067)	(0.067)
Age 80+	-0.398**	-0.401**	-0.396**
	(0.185)	(0.185)	(0.185)
Male vs female	-0.599***	-0.587***	-0.598***
	(0.073)	(0.075)	(0.073)
Not married vs married	0.494***	0.495***	0.496***
	(0.116)	(0.116)	(0.116)
Years of formal schooling	-0.079***	-0.079***	-0.079***
	(0.009)	(0.009)	(0.009)
Social engagement (rf.: not active)			
Active	-0.499***	-0.499***	-0.470***
	(0.086)	(0.086)	(0.089)
Family income quintile	-0.175***	-0.174***	-0.175***
	(0.012)	(0.012)	(0.012)
Urban vs rural residence	-0.440***	-0.441***	-0.440***
	(0.074)	(0.074)	(0.074)
Living alone × Male		-0.142	
		(0.238)	
Living alone × Active			-0.374
			(0.297)
Constant	11.24***	11.23***	11.23***
	(0.090)	(0.091)	(0.091)

Note: Number of observations=18,938; Number of respondents=9,469; *p<0.05; **p<0.01; ***p<0.001; Standard errors in parentheses.