

Social isolation, rather than loneliness, is associated with cognitive decline in older adults: the China Health and Retirement Longitudinal Study

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Running title: Isolation, loneliness and cognition

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Word counts in text: 4125

Conflicts of Interest: None

1 **Abstract**

2 **Background:** Social isolation and loneliness have each been associated with cognitive decline,
3 but most previous research is limited to Western populations. This study examined the
4 relationships of social isolation and loneliness on cognitive function among Chinese older
5 adults.

6 **Methods:** This study used two waves of data (2011 and 2015) from the China Health and
7 Retirement Longitudinal Study (CHARLS) and analyses were restricted to those respondents
8 aged 50 and older. Social isolation, loneliness and cognitive function were measured at baseline.
9 Follow-up measures on cognitive function were obtained for 7,761 participants (mean age =
10 60.97, SD = 7.31; male, 50.8%). Lagged dependent variable models adjusted for confounding
11 factors were used to evaluate the association between baseline isolation, loneliness, and
12 cognitive function at follow-up.

13 **Results:** Loneliness was significantly associated with the cognitive decline at follow-up
14 (episodic memory: $\beta = -0.03$, $p < 0.01$; mental status: $\beta = -0.03$, $p < 0.01$) in the partially
15 adjusted models. These associations became insignificant after additional confounding
16 variables (chronic diseases, health behaviors, disabilities and depressive symptoms) were taken
17 into account (all $p > 0.05$). By contrast, social isolation was significantly associated with
18 decreases in all cognitive function measures at follow-up (episodic memory: $\beta = -0.05$, $p <$
19 0.001 ; mental status: $\beta = -0.03$, $p < 0.01$) even after controlling for loneliness and all
20 confounding variables.

21 **Conclusions:** Social isolation is associated with cognitive decline in Chinese older adults, and
22 the relationships are independent of loneliness. These findings expand our knowledge about the
23 links between social relationships and the cognitive function in non-Western populations.

24 **Keywords:** social isolation, loneliness, cognitive function, older adults.

25

1 **Introduction**

2 Population aging is one of the major challenges worldwide. China has the world’s largest aging
3 population of older adults. By 2050, the number of Chinese people aged 60 and older is
4 expected to reaching 479 million (DESA, 2017). In parallel with this aging profile, the number
5 of Chinese older adults with dementia is projected to reach 18 million in 2030 (Chan et al.,
6 2013). Dementia makes a major contribution to disability and health care needs among older
7 people. The enormous disease burden has made the prevention and treatment of dementia public
8 health priorities for China.

9 Increasing efforts have been made to identify modifiable factors that may prevent or slow
10 the progression of cognitive decline in older age, and impoverished social relationships —
11 defined as social isolation or loneliness — have received considerable attention. Accumulated
12 evidence has shown that both social isolation (Evans, Martyr, Collins, Brayne, & Clare, 2018;
13 Kuiper et al., 2016) and loneliness (Boss, Kang, & Branson, 2015; Cacioppo & Hawkley, 2009)
14 affect cognitive function. Although loneliness and social isolation are sometimes perceived to
15 be synonymous, they are conceptually different. In essence, social isolation refers to the
16 objective aspects of isolation, such as living alone, having few contacts, or little involvement
17 in social activities (Holt-Lunstad, Smith, Baker, Harris, & Stephenson, 2015). In contrast,
18 loneliness refers to a subjective feeling resulting from a discrepancy between actual and desired
19 social relationships (Peplau & Perlman, 1982). Even socially connected individuals can feel
20 lonely, just as socially isolated individuals can be satisfied with their social relationships.
21 Studies have found that correlations between loneliness and social isolation are generally
22 moderate (Cornwell & Waite, 2009; McHugh, Kenny, Lawlor, Steptoe, & Kee, 2017).

23 It has been suggested that analyzing both objective and subjective aspect of social
24 relationship in the same study can allow us to better understand how these two social constructs
25 affect health (Cornwell & Waite, 2009; Holt-Lunstad et al., 2015; Newall & Menec, 2019).
26 However, researchers have mostly examined relationship with cognitive impairment of only
27 one construct, either loneliness or social isolation (Boss et al., 2015; Evans et al., 2018; Kuiper

1 et al., 2016). Among the few studies in which loneliness and social isolation were examined
2 concurrently, there were mixed results. Some findings support the greater association of
3 loneliness (Holwerda et al., 2014) and some findings support the greater association of social
4 isolation in predicting with cognitive decline (Beller & Wagner, 2018; Griffin, Mezuk,
5 Williams, Perrin, & Rybarczyk, 2018). Synergistic effects of loneliness and social isolation on
6 cognitive function were also found by some researchers. For example, analysis from the Rush
7 Memory and Aging Project found that participants who were lonely and those with limited
8 participation in social activities were more likely to develop Alzheimer's disease (R. S. Wilson
9 et al., 2007). A longitudinal study with English older adults also indicated that both social
10 isolation and loneliness were significantly associated with poorer cognitive function (Shankar,
11 Hamer, McMunn, & Steptoe, 2013). More information is needed regarding both the relative
12 and synergistic influences of social isolation and loneliness on cognitive function.

13 Meanwhile, another gap in knowledge is the lack of studies on the cognitive consequences
14 of social isolation and loneliness in non-Western countries. Most studies on this topic have been
15 conducted in North America and European countries (Courtin & Knapp, 2017; Evans et al.,
16 2018; Kuiper et al., 2016), and it is not established whether similar patterns occur in other
17 cultures. The importance of such research is underscored by the fact that isolation and loneliness
18 are equally prevalent in non-Western as in Western countries. The proportion of empty-nest
19 families (refers to those older people with no children or whose children have already left home)
20 in China is estimated to reach 90% by 2030 (Rafnsson, Orrell, d'Orsi, Hogervorst, & Steptoe,
21 2017). It has been suggested that the association between social relationships and health could
22 be more salient in Chinese populations, for whom cultural tradition emphasizes the family
23 system and collectivism (Yang & Victor, 2008). However, only a few studies have investigated
24 the impact of social relationships on cognitive function among older adults and most were
25 limited by small sample size or cross-sectional design (Fung, Lee, Cheng, & Lam, 2019; Wang
26 et al., 2012). Two recent publications based on the Chinese Longitudinal Healthy Longevity
27 Survey using relatively large sample size have reported the negative impact of poor social

1 relationships on cognitive function. However, both of these studies mainly focused
2 on loneliness rather than social isolation (Zhong, Chen, & Conwell, 2016; Zhong, Chen, Tu, &
3 Conwell, 2017).

4 Given that very few studies examined loneliness and social isolation simultaneously in
5 relation to cognition in non-Western populations, and the inconclusive findings in this area, we
6 used data from the China Health and Retirement Longitudinal Study (CHARLS) to examine
7 the impact of social isolation and loneliness, individually and simultaneously, on cognitive
8 function among Chinese older adults. We hypothesize that both social isolation and loneliness
9 would be significantly associated with cognitive decline over 4 years. However, we made no
10 specific assumption about which of these two factors might play a stronger role in the light of
11 existing mixed results. Regarding previous evidence indicating possible gender differences in
12 the association between social relationship factors and health (Shumaker & Hill, 1991; Shye,
13 Mullooly, Freeborn, & Pope, 1995), we also tested the interaction of gender with social
14 isolation and loneliness on cognitive function for our sample.

1 **Methods**

2 *Participants*

3 Data are from the China Health and Retirement Longitudinal Study (CHARLS), a nationally
4 representative longitudinal survey sampled residents from 150 counties across 28 provinces in
5 China, with a response rate of 80.5% (Zhao, Hu, Smith, Strauss, & Yang, 2012). The CHARLS
6 is one of the most up-to-date longitudinal data sets collected in China to study the health and
7 well-being of older adults. The survey assigned 23,422 dwelling units to interviewers at
8 baseline in 2011. After excluding empty or non-resident dwellings, 12,740 were age-eligible
9 for CHARLS (Zhao et al., 2012). In the present study, we used data from two waves of the
10 CHARLS collected in 2011 and 2015. The baseline sample included 17,708 respondents. Our
11 analytic sample was restricted to those respondents aged 50 and older (n = 13,649). We
12 excluded those respondents who had missing values on any predictor or cognitive test at
13 baseline (n = 3,506) or cognitive test at follow-up (n = 2,382), which resulted in a final sample
14 size of 7,761 respondents (mean age = 60.97, SD = 7.31; male, 50.8%).

15 *Measures*

16 **Loneliness**

17 In our study, loneliness was measured with one single item included in the Centre for
18 Epidemiological Studies Depression Scale (CESD): “In the last week, how often did you feel
19 lonely?”. The respondent chose among four ordinal responses scored 1 to 4: rarely or none of
20 the time (< 1 day), some or a little of the time (1-2 days), occasionally or a moderate amount
21 of the time (3-4 days), most or all of the time (5-7 days).’ This one item measure correlates
22 highly with multi-item loneliness scales and has been used in a number of previous studies
23 (Gow, Corley, Starr, & Deary, 2013; Holwerda et al., 2014; Luo & Waite, 2014; Nummela,
24 Seppanen, & Uutela, 2011; Tilvis, Pitkala, Jolkkonen, & Strandberg, 2000). Loneliness was
25 dichotomized into 2 categories (0 [not lonely] = those who reported feeling lonely rarely or
26 none of the time, and 1 [lonely] = those who felt lonely sometimes, occasionally or most of
27 the time) (Teguo et al., 2016).

1 **Social isolation**

2 Three items were combined to create an index of social isolation, which was adapted from
3 previous research (Glei, Goldman, Ryff, Lin, & Weinstein, 2012; Steptoe, Shankar,
4 Demakakos, & Wardle, 2013). One point was assigned if participants were not married; had
5 less than weekly contact (by phone, in person, or by e-mail) with children, not participating
6 in any social activities over the last month (e.g., interacted with friends; played chess or cards;
7 going to the community club; went to a sport, social, or other club; did voluntary or charity
8 work). Scores of social isolation ranged from 0 to 3, with higher scores indicating greater
9 isolation.

10 **Cognitive assessment**

11 CHARLS included similar items for cognitive function as those used in the American Health
12 and Retirement Study (HRS), which were components of the Telephone Interview for
13 Cognitive Status (TICS) (Crimmins, Kim, Langa, & Weir, 2011). McArdle et al. (2007)'s
14 study of the HRS data suggested two factors to adequately capture cognitive function
15 (McArdle, Fisher, & Kadlec, 2007). Following McArdle et al. and based upon previous
16 studies using the CHARLS data (Lei, Hu, McArdle, Smith, & Zhao, 2012; Pan, Luo, &
17 Roberts, 2018), we constructed two measures of cognitive function. The first is an episodic
18 memory measurement. In CHARLS, memory was assessed through an immediate word recall
19 based on respondents' capacity to immediately repeat in any order a list of 10 Chinese nouns
20 just read to them, followed by a delayed recall that tests respondents' ability to repeat the
21 same list of words four to ten minutes later (Crimmins et al., 2011). The episodic memory
22 measure was created by averaging the immediate and delayed recall scores, and scores ranged
23 from 0 to 10. The second cognitive measure is based on components of the mental status
24 questions of the TICS established to capture the intactness or mental status of individuals.
25 Orientation was assessed by asking respondents to name today's date (month, day, year), and
26 identify the correct day of the week. Visuospatial ability was assessed by asking respondents
27 to accurately re-draw a previously shown picture. Numeric ability was assessed through the

1 serial subtraction of 7 from 100 (up to five times). Scores on these items were aggregated
2 into a single score that ranged from 0 to 10 and was labeled as mental status, as recommended
3 by McArdle et al (2007). For both measures, higher scores indicate better cognitive function.

4 **Control variables in the baseline survey**

5 The analyses were adjusted for several demographic variables and behavioural, psychological
6 and clinical risk factors. Age, gender, education and area of residence (urban/rural) were
7 measured by self-report. Education was dichotomized as lower than secondary school and
8 secondary school or above. Health habits including drinking and smoking, were collected
9 using a standardized questionnaire (Zhao et al., 2012). Respondents were asked whether they
10 were current smokers and whether they consumed alcohol in the past 12 months. Two
11 measures of functional limitation were considered. CHARLS asked respondents if they
12 required assistance with any of 6 activities of daily living (ADLs: walking, dressing, bathing,
13 eating, getting into and out of bed, and toileting) or 5 instrumental ADLs (IADLs: preparing
14 a hot meal, shopping for groceries, making telephone calls, taking medicines, and managing
15 money) (Lei et al., 2014). Both ADLs and IADLs were treated as binary predictors (1 =
16 functional limitations present; 0 = no functional limitations present) due to most respondents
17 (ADL: 83.8%; IADL: 80%) denying any limitations. Chronic diseases including hypertension,
18 diabetes and heart diseases were obtained by asking respondents if a physician had ever told
19 them that they had the condition. Depressive symptoms were measured with 10-item Center
20 for Epidemiological Studies Depression Scale (CESD-10). Modified CESD scoring was used
21 to exclude the loneliness question in order to derive a separate depression score that was
22 calculated as the sum of the remaining nine questions (CESD-9, range 0–27).

23 **Statistical Analysis**

24 Characteristics of the overall sample at baseline were described using means and standard
25 deviations for continuous data and percentages for categorical data. Rank order correlations
26 were used to assess correlations between key predictors including loneliness (continuous scores
27 ranged from 1 to 4 were used) and social isolation and other variables included in the analyses.

1 To examine the association between isolation, loneliness and cognitive function, we used
2 lagged dependent variable regression models with Ordinary Least Squares estimation. The
3 lagged dependent variable model is superior for analyzing the effects of predictor variables on
4 an outcome with two-wave panel data while controlling for the influence of time-invariant
5 variables (Johnson, 2005). Seven models were fitted for both cognitive measurements. Model
6 1A was constructed to examine the associations between loneliness at baseline and cognitive
7 function at follow-up by partially adjusting for control variables including age, gender,
8 education, area of residence, and baseline cognitive function. Other control variables including
9 chronic diseases, smoking and drinking status, ADL and IADL disabilities were then added in
10 Model 1B. Model 1C added CESD-9 scores in the fully adjusted model. Three similar models
11 were fitted to test the independent associations of isolation with cognitive function (Model 2A,
12 B, & C). Model 3 added both isolation and loneliness into the fully adjusted model. We tested
13 whether there was an interaction effect between isolation and loneliness on cognitive function
14 by including appropriate interaction terms into the fully adjusted model. The interactions
15 between isolation, loneliness and gender were also assessed. For all regression analyses,
16 standardized regression coefficients (β) were reported as variables under study were measured
17 on different scales. Analyses were carried out using SPSS version 20.0.

18

1 **Results**

2 **Table 1** shows the characteristics of the participants under study at baseline and their correlation
3 with isolation and loneliness. The mean age of participants was just over 60 years, and more
4 than half were men. When compared with those who were excluded from the original sample
5 ($n = 5,888$), participants included in the study sample ($n = 7,661$) were more likely to be male
6 (50.8% vs 47.9%; $p = 0.001$), younger (mean age in years: 60.97 vs 64.05, $p < 0.001$) and living
7 in rural area (62.3% vs 56.8%; $p < 0.001$). They were more likely to be current smoker (32.9%
8 vs 25.4%; $p < 0.001$) and drinker (34.1% vs 30.2%; $p < 0.001$), were less likely to have
9 hypertension (28.4% vs 31.5%; $p = 0.001$), ADL disabilities (16.2% vs 24.1%; $p < 0.001$) and
10 IADL disabilities (20.0% vs 30.3%; $p < 0.001$). In addition, individuals who were included into
11 the study sample were more likely to feel lonely (35.7% vs 28.1%, $p < 0.001$), had a lower level
12 of depressive symptoms (mean CESD-9 score: 6.80 vs 7.71, $p < 0.001$), lower level of isolation
13 (mean score: 0.76 vs 0.90; $p < 0.001$) and both their episodic memory (mean score: 3.50 vs
14 3.09; $p < 0.001$) and mental status (mean score: 6.57 vs 5.50; $p < 0.001$) were better than those
15 who were excluded from the analysis.

16 Of all the participants, the mean scores (SD) for loneliness and social isolation was 1.52
17 (0.94) and 0.76 (0.67) respectively, with 28.1% reported that they felt lonely sometimes,
18 occasionally or most of the time. 15.3% of participants were unmarried. Unadjusted
19 correlations between baseline control variables included in the analyses and isolation and
20 loneliness were evaluated (**Table 1**). Being more socially isolated or lonelier was associated
21 with being females, older, less educated, living in rural area, being a drinker, having more ADL
22 and IADL disabilities, and a higher level of depressive symptoms. Diagnosed hypertension was
23 positively associated with loneliness but negatively associated with isolation, as was diagnosed
24 heart diseases. Diagnosed diabetes was only negatively associated with isolation. Loneliness
25 was positively associated with every sub-dimension of isolation and moderately correlated with
26 the total score of isolation ($\rho = 0.17$, $p < 0.001$). After 4 years, the mean scores on both episodic
27 memory (from 3.50 to 3.12) and mental status (from 6.57 to 6.11) were significantly lower ($t =$

1 18.07, $p < 0.001$ for memory; $t = 14.93$, $p < 0.001$ for mental status).

2 **Tables 2 and 3** show the results of lagged regression on episodic memory and mental
3 status respectively. Loneliness was significantly associated with cognitive decline (episodic
4 memory: $\beta = -0.03$, $p = 0.002$; mental status: $\beta = -0.03$, $p = 0.002$) after 4 years when five
5 control variables including age, gender, education, area of residence and baseline episodic
6 memory or mental status score were adjusted (Model 1A). These associations remain significant
7 when other covariates such as chronic disease, health behaviors and disabilities were included
8 in the models (Model 1B). However, these associations were no longer significant (episodic
9 memory: $\beta = -0.02$, $p = 0.179$; mental status: $\beta = -0.02$, $p = 0.088$) when CESD-9 were adjusted
10 (Model 1C). In contrast, greater isolation was significantly associated with lower scores on
11 episodic memory ($\beta = -0.04$, $p < 0.001$) and mental status ($\beta = -0.03$, $p = 0.003$) 4 years later
12 even after all the covariates including CESD-9 scores were taken into account (Model 2C).
13 Adding loneliness to the model did not reduce the association with isolation (Model 3). The
14 interaction terms between isolation and loneliness were not statistically significant for episodic
15 memory (p for interaction = 0.690) or mental status (p for interaction = 0.050), indicating that
16 there was no synergistic effect between isolation and loneliness on cognitive decline. Isolation
17 \times gender interaction was tested by adding the terms into the fully adjusted model including
18 isolation and loneliness. This interaction term was neither significant for episodic memory (p
19 for interaction = 0.934) nor for mental status (p for interaction = 0.224). No significant
20 interaction between gender and loneliness was found for either cognitive measure (all p for
21 interaction > 0.5).

22 To reduce the risk of reverse causation in analyses, we reran Model 3 after excluding the
23 respondents with very low cognition scores at the baseline survey (bottom 10%), on the grounds
24 that people with very impaired cognition may find it difficult to engage socially with others.
25 The results were unchanged [for episodic memory: isolation ($\beta = -0.04$, $p = 0.001$); loneliness
26 ($\beta = -0.02$, $p = 0.064$). for mental status: isolation ($\beta = -0.03$, $p = 0.013$); loneliness ($\beta = -0.02$,
27 $p = 0.111$)].

1 **Discussion**

2 In this study, a large representative sample of Chinese older adults was selected to examine
3 simultaneously the associations of social isolation and loneliness with cognitive decline over a
4 4-year follow-up period. In accordance with our hypotheses, both loneliness and social isolation
5 showed association with decreases in episodic memory and mental status. However, this
6 association become less significant for loneliness when all the other confounding variables,
7 especially depressive symptoms, were taken into account. While the association for social
8 isolation seems independent of loneliness and other confounding variables. Our results seem to
9 indicate a stronger negative relationship between social isolation than loneliness and cognitive
10 function, which is consistent with two recent studies. For instance, Griffin et al found that social
11 isolation was longitudinally associated with worse cognitive performance in older Americans
12 whereas loneliness only cross-sectionally correlated with lower cognitive function (Griffin et
13 al., 2018). Another longitudinal study with German older adults also found that social isolation
14 rather than loneliness can predict cognitive health (Beller & Wagner, 2018).

15 Substantial evidence indicated that loneliness is associated with a higher risk of cognitive
16 decline at older ages (Boss et al., 2015), and may contribute to the development of dementia
17 (Rafnsson et al., 2017; R. S. Wilson et al., 2007). However, contradictory evidence also exists
18 that indicates no independent association between loneliness and cognitive decline (Okely &
19 Deary, 2018; Rawtaer et al., 2017). Two studies with Chinese older adults found a significant
20 association between loneliness and cognitive decline. Although loneliness was measured with
21 one single item in these two studies as ours, depressive symptoms were not controlled in their
22 models (Zhong et al., 2016; Zhong et al., 2017). Our study does indicate negative associations
23 between loneliness and cognitive function. However, these relationships become non-
24 significant when all the confounding variables including depressive symptoms were controlled.
25 It is notable that in our study, the associations between loneliness and baseline poor health was
26 stronger than the associations between social isolation and the same health index, especially for
27 cardiovascular health and depressive symptoms. Therefore, our finding that loneliness no

1 longer was associated with cognitive decline after these confounding variables had been
2 controlled may reflect its association with baseline health. Accounting for depressive symptoms
3 did more to reduce the association between cognitive function than accounting for the clinical
4 and behavioral covariates. Loneliness was measured by one item from CESD in our study, and
5 the two are significantly correlated ($\rho=0.45$, $p<0.001$). Thus, it is not a surprise that controlling
6 for depressive symptoms would reduce the size of the association. Such a result is consistent
7 with previous studies. In a longitudinal study of Scottish aging adults, the associations between
8 loneliness and cognitive ability were no longer significant when the model included depressive
9 symptoms as covariates (Gow et al., 2013). Similar results were also found for studies of
10 mortality (Steptoe et al., 2013; Teguo et al., 2016). In a cohort study adopted a same
11 measurement of loneliness as ours, the association between loneliness and mortality also
12 became insignificant when depressive symptoms (CESD scores excluding loneliness item)
13 were adjusted (Teguo et al., 2016). These results may not imply that loneliness is not important
14 but rather indicate that the experience of loneliness may be characteristic of people who already
15 have mental health problems. Future studies with more independent measurements of loneliness
16 and depressive symptoms are warranted to clarify this issue.

17 Nevertheless, convincing evidence, including the present study, highlights the associations
18 between social isolation and cognitive decline (Kuiper et al., 2016). Several theories have been
19 proposed to explain the association of social isolation and cognitive function. One is the ‘use it
20 or lose it’ theory (Hultsch, Hertzog, Small, & Dixon, 1999), which argues that engagement in
21 intellectual, physical and social activities stimulates the brain. Decrease in engagement in social
22 activities may result in lack of use of mental faculties that may in turn lead to a decline of
23 cognitive ability. Another theory is stress-buffering, proposing that social relationships are
24 beneficial in stressful situations (Fratiglioni, Paillard-Borg, & Winblad, 2004). Stress has been
25 associated with cognitive decline due to structural changes in the hippocampus (R. Wilson et
26 al., 2003). Social relationships may prevent or modulate responses to stressful events that are
27 damaging to health.

1 Although previous studies provide evidence for the negative associations between social
2 relationships and cognitive function, it should be noted that most findings are based on Western
3 sample and hence a limited cultural context (Courtin & Knapp, 2017; Evans et al., 2018; Kuiper
4 et al., 2016). Westerners tend to have higher objective social isolation compared with non-
5 Western populations. Taking the USA as an example, the percentage of single-person
6 households within the same historical period is almost three times that of China (Hu & Peng,
7 2015). Furthermore, Western countries tend to be more individualistic from a cultural viewpoint
8 (Hofstede, Hofstede, & Minkov, 2005). Thus, our study expands knowledge about the role of
9 social relationships in a more collectivistic culture.

10 Strengths of our study include the large sample size and the fact that CHARLS is designed
11 to be representative of the community-dwelling Chinese population aged ≥ 50 . Cognitive
12 function was assessed with a series of objective tests, and the study benefited from detailed
13 measures of potential confounders. The study also has limitations. First, loneliness was assessed
14 with only one direct question regarding the perception of loneliness in the last week. Despite
15 wide use in the literature and strong correlations with several established multiple-item scales,
16 this measure may be less reliable than a composite measure that taps multiple aspects of
17 loneliness (Holwerda et al., 2014; Petersen et al., 2016; Victor, Grenade, & Boldy, 2005). The
18 effects of loneliness became insignificant when depressive symptoms were adjusted, which
19 may also be because the loneliness item is derived from the CESD-10. However, another study
20 using a more complex and independent measure of loneliness have reported similar findings as
21 ours (Griffin et al., 2018). Second, the present study investigated the consequences of loneliness
22 and social isolation longitudinally with a relative short-term of 4 years. This prevent us from
23 examining long-term association of social relationships with cognitive function, and whether
24 certain aspects of social relationships become more or less important over time. Future work
25 could test the relationship using longer-term panel data of Chinese population. Third, CHARLS
26 does not give full neuropsychological testing for the large sample at baseline, and thus cannot
27 provide formal diagnoses of mild cognitive impairment (MCI) or dementia. However, we have

1 applied a widely used way to exclude the respondents with very low cognition scores (bottom
2 10%) at the baseline survey (Ganguli et al., 1993; Weuve et al., 2004). A sensitivity analysis
3 after the exclusion yielded similar results as the primary analysis. Finally, this is an
4 observational study, and causal conclusions cannot be drawn. Although we took multiple
5 covariates into account, there may be other unmeasured factors responsible for the associations
6 recorded here.

1 **Conclusion**

2 In this prospective study, high levels of social isolation were associated with an increased risk
3 of cognitive decline. By contrast, loneliness was not linked with the cognitive decline when
4 other confounding variables were controlled. These findings expand our knowledge about the
5 association of social relationships with cognitive function in non-Western populations.
6 Cognitive decline is a strong risk factor for development of dementia (Bennett et al., 2002).
7 Efforts to reduce isolation may therefore have substantial benefits in terms of preventing
8 dementia among older adults in China.

9

10 **Acknowledgments**

11 This work was supported by the National Social Science Foundation, China (grant numbers
12 18BSH118)

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Table 1 Baseline characteristics of the participants (n = 7,761)

Characteristic	Mean (SD), or, %	Correlation with loneliness	Correlation with social isolation
Age, M (SD), y	60.97 (7.31)	0.060***	0.106***
Gender (male, %)	50.8	-0.100***	-0.060***
Education (Less than lower secondary education, %)	88.7	-0.080***	-0.131***
Residence (Live in the urban area, %)	37.7	0.102***	0.095***
Hypertension, %	28.4	0.048***	-0.002
Diabetes, %	6.8	0.005	-0.042***
Heart diseases, %	14.0	0.058***	-0.029*
Smoking, %	32.9	-0.022	-0.024*
Drinking, %	34.1	-0.047***	-0.061***
ADL disability, %	16.2	0.190***	0.102***
IADL disability, %	20.0	0.175***	0.102***
CESD-9, M (SD)	6.80 (5.79)	0.454***	0.152***

Baseline cognitive function			
Episodic memory, M (SD)	3.50 (1.63)	-0.118***	-0.143***
Mental Status, M (SD)	6.57 (2.84)	-0.184***	-0.172***
Loneliness, M (SD)	1.52 (0.94)	–	0.165***
Social isolation, M (SD)	0.76 (0.67)	0.187***	–
Not married, %	15.3	0.225***	0.487***
Less than weekly contact with children, %	8.2	0.048***	0.379***
Not participate in social activities, %	52.5	0.044***	0.768***

M, mean; SD, standard deviation; ADL, activities of daily living; IADL, instrumental activities of daily living; CESD, Center for Epidemiologic Studies Depression scale.

* $p < .05$, ** $p < .01$, *** $p < .001$.

Table 2. Predicting episodic memory at follow-up

	Model 1			Model 2			Model 3
	A (β)	B (β)	C (β)	A (β)	B (β)	C (β)	(β)
Age	-0.22***	-0.22***	-0.22***	-0.22***	-0.22***	-0.22***	-0.22***
Gender	0.01	0.02	0.02	0.01	0.02	0.02	0.02
Education	0.13***	0.13***	0.13***	0.13***	0.13***	0.12***	0.12***
Residence	-0.11***	-0.10***	-0.10***	-0.11***	-0.10***	-0.10***	-0.10***
Baseline EM	0.33***	0.32***	0.32***	0.33***	0.32***	0.32***	0.32***
Loneliness	-0.03**	-0.03*	-0.02	-	-	-	-0.01
Isolation		-	-	-0.05***	-0.04***	-0.04***	-0.04***
Hypertension		-0.00	-0.00		-0.00	-0.00	-0.00
Diabetes		-0.00	-0.00		-0.01	-0.00	-0.00
Heart diseases		0.05***	0.05***		0.05***	0.05***	0.05***
Smoking		-0.03*	-0.03*		-0.03*	-0.03*	-0.03*
Drinking		0.01	0.01		0.01	0.01	0.01
ADL disability		0.00	0.01		0.00	0.01	0.01
IADL disability		-0.06***	-0.06***		-0.06***	-0.06***	-0.06***
CESD-9			-0.03*			-0.03*	-0.03*

β = standardized regression coefficient.

EM, episodic memory; ADL, activities of daily living; IADL, instrumental activities of daily living; CESD, Center for Epidemiologic Studies Depression scale.

* $p < .05$, ** $p < .01$, *** $p < .001$.

Table 3. Predicting mental status at follow-up

	Model 1			Model 2			Model 3
	A (β)	B (β)	C (β)	A (β)	B (β)	C (β)	(β)
Age	-0.11***	-0.11***	-0.11***	-0.11***	-0.11***	-0.11***	-0.11***
Gender	0.12***	0.14***	0.13***	0.12***	0.14***	0.14***	0.13***
Education	0.08***	0.08***	0.08***	0.08***	0.08***	0.08***	0.08***
Residence	-0.08***	-0.08***	-0.07***	-0.08***	-0.08***	-0.08***	-0.07***
Baseline MS	0.49***	0.49***	0.48***	0.49***	0.48***	0.48***	0.48***
Loneliness	-0.03**	-0.03**	-0.02	-	-	-	-0.02
Isolation		-	-	-0.03**	-0.03**	-0.03**	-0.02**
Hypertension		0.02	0.02		0.01	0.01	0.01
Diabetes		-0.00	-0.00		-0.00	-0.00	-0.00
Heart diseases		0.02*	0.03**		0.02*	0.02*	0.02*
Smoking		-0.03*	-0.03*		-0.03**	-0.03**	-0.03*
Drinking		0.01	0.01		0.00	0.00	0.00
ADL disability		0.01	0.01		0.01	0.01	0.01
IADL disability		-0.03**	-0.03**		-0.04***	-0.03**	-0.03***
CESD-9			-0.03*			-0.03**	-0.02*

β = standardized regression coefficient.

MS, mental status; ADL, activities of daily living; IADL, instrumental activities of daily living; CESD, Center for Epidemiologic Studies Depression scale.

* $p < .05$, ** $p < .01$, *** $p < .001$