A Cross-lagged Panel Analysis of Social Participation in the Relationship Between Functional Limitations and Cognitive Functioning: Evidence from CHARLS

Alex Pak Lik Tsang, PhD[1]
Chi Ko Lee[1]
Stephen Cheong Yu Chan, PhD[2]

[1]Department of Applied Social Sciences, The Hong Kong Polytechnic University, Hong Kong
[2]Felizberta Lo Padilla Tong School of Social Sciences, Saint Francis University, Hong Kong

Author's Note

Correspondence of this article should be addressed to Alex Pak Lik Tsang: pak-lik-alex.tsang@connect.polyu.hk

Acknowledgments

None.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The research received no specific grant from any funding agencies.

Ethical Statement

CHARLS was ethically reviewed and approved by the Ethical Review Committee of Peking University (IRB00001052-11015).

Data Availability Statement

CHARLS is a publicly accessible database.

ORCID iDs

Alex Pak Lik Tsang https://orcid.org/0000-0003-2919-1587
Chi Ko Lee https://orcid.org/0009-0008-1334-1687
Stephen Cheong Yu Chan https://orcid.org/0000-0003-4240-0742

Author Contributions

Alex Pak Lik Tsang and Stephen Cheong Yu Chan were responsible for study concept and design. Alex Pak Lik Tsang and Chi Ko Lee were responsible for analysis and interpretation of data. Alex Pak Lik Tsang, Chi Ko Lee and Stephen Cheong Yu Chan were responsible for drafting and critical revision of the manuscript for important intellectual content. Alex Pak Lik Tsang was responsible for final revision for submission.

A Cross-lagged Panel Analysis of Social Participation in the Relationship Between Functional Limitations and Cognitive Functioning: Evidence from CHARLS

Abstract

Functional limitations refer to the dependency to perform activities of daily living. Increasing evidence has demonstrated a bidirectional association between functional limitations and cognitive functioning, although the exact mechanism remains unclear. This study investigated whether social participation bidirectionally mediates the association between functional limitations and cognitive decline. We analysed a sample of 16,385 middle-aged and older adults (aged over 50 years) using longitudinal data from the China Health and Retirement Longitudinal Study (CHARLS; Waves 1-4). We utilised a cross-lagged panel model to examine the bidirectional mediation of social participation between functional limitations and cognitive functioning over a span of eight years. The results indicated that social participation bidirectionally and partially mediated the relationship between the onset of functional limitations and cognitive decline, indicating that social participation may play an important role in mitigating the disablement process.

Keywords: basic activities of daily living, cognitive functioning, cross-lagged panel analysis, functional limitations, instrumental activities of daily living, older adults, social participation

What this paper adds

- This study represents a novel investigation into how social participation bidirectionally mediates the relationship between functional limitations and cognitive decline.
- Social participation partially mediated the impact of functional limitations on cognitive decline, and vice versa.
- During the onset of functional limitations or cognitive decline, social participation may exert a protective effect through stress buffering.

Applications of study findings

- Social participation should be incorporated when investigating the relationship between functional abilities and cognitive functioning to advance theoretical understanding and empirical findings.
- Early identification and targeting of individuals with functional limitations and cognitive decline enable healthcare providers to foster social inclusion through low-intensity activities, mitigating the disablement process.
- Social participation should be promoted by increasing awareness campaigns about social prescribing benefits and creating age-friendly environments to support older adults' holistic health.

Introduction

Functional limitations often arise during late middle age and can persist into old age (Brown et al., 2019). These limitations are typically operationalised as the dependency in performing basic activities of daily living (ADL), such as dressing, bathing, feeding, getting in or out of bed, and toileting, as well as instrumental activities of daily living (IADL), including cooking, housework, shopping, managing finances, medication management, and using telephones (Katz et al., 1963; Lawton & Brody, 1969). According to the Disablement

Process Model, functional limitations are often the precursors of a more severe form of functional disability, characterised by a further loss of independence in major life domains (Verbrugge & Jette, 1994). Not only do functional limitations have substantial impacts on an individual's quality of life, but they can also impose a greater caregiving burden on informal carers (Dombrowsky, 2017; Nichols et al., 2008). Furthermore, functional limitations result in increased hospitalisations, which inflict a substantial amount of financial burden on the healthcare system (Wróblewska et al., 2018). According to the 2018 Chinese Family Panel Studies, the estimated prevalence rate of functional limitations among middle-aged and older adults in China is 14.3% (Lin, 2023). As the population continues to age in China, a rising prevalence of functional limitations is anticipated because functional limitations are strongly associated with ageing, in part due to the presence of various age-related chronic diseases (Hu et al., 2021). To provide timely interventions for individuals at an early onset of functional limitations, it is crucial to develop a comprehensive understanding of the underlying mechanisms and outcomes associated with these limitations.

Extensive research has demonstrated that cognitive functioning plays a crucial role in the disablement process. Cognitive functioning has been consistently identified as a predictor of the onset of functional limitations (e.g., Sun et al., 2022). This association may be attributed, in part, to the shared components between functional abilities and cognitive functioning. Subdomains of cognitive functioning, such as executive function, memory, and attention, are required in many ADLs and IADLs (Burdick et al., 2005; Royall et al., 2004). Conversely, functional limitations are often considered a risk factor for cognitive decline (Farias et al., 2017). More recently, a longitudinal study analysing over 13 years of cross-lagged panel data indicated a reciprocal relationship between cognitive functioning and functional limitations (Martin et al., 2023). In other words, the onset of functional limitations can contribute to cognitive decline, which in turn further impacts functional abilities, and vice versa. However, much less is known about the reinforcing mechanisms within this association. Understanding these mechanisms is crucial to inform effective interventions aimed at mitigating the negative reciprocal relationship between functional limitations and cognitive decline.

A plausible explanation for the reciprocal relationship between functional limitations and cognitive functioning might be that as functional limitations or cognitive decline emerge, individuals may withdraw from social participation due to restrictions in physical and cognitive functioning, which could contribute to further cognitive and functional declines (Hwang et al., 2022; Rosso et al., 2013). According to the Stress-Buffering Hypothesis, social support can act as a buffer to help individuals navigate and cope with stressful life events (Cohen & Wills, 1985). Experiencing restrictions in functional abilities or cognitive functioning can be significant life stressors (Pearlin & Skaff, 1996). Supportive social relationships can attenuate activations of hypothalamic-pituitary-adrenal (HPA) axis and sympathetic nervous system (SNS) during stressful events, which in turn can exert protective effects on cognitive and physical functioning (Seeman & McEwen, 1996). However, individuals with functional limitations often prioritise health-related activities, such as self-care and medical appointments, over engaging in social interactions (Fingerman et al., 2021). Similarly, those with cognitive decline may devote more effort to performing IADLs, leading to fewer social interactions (Rotenberg et al., 2020). Yet, social participation could be an important source of social support (Li et al., 2018). For example, participating in social activity (SA) is observed to be beneficial for cognitive health in older adults (Yang et al., 2020), while a lower level of social participation can be a risk factor for incident dementia and subsequent functional declines (Kuiper et al., 2015). Collectively, this suggests that social participation plays a crucial role in intervening in the disablement process and could potentially mediate the relationship between the onset of functional limitations and cognitive decline.

With an ageing population and an increased prevalence of functional limitations and cognitive decline, there is a need to gain a comprehensive understanding of the underlying mechanisms between functional limitations and cognitive functions. Confirming the directionality through which social participation mediates the association between functional limitations and cognitive functioning can inform social support interventions, helping to identify and target vulnerable populations to mitigate the reinforcing mechanisms between the onset of functional limitations and cognitive decline. Therefore, to address this knowledge gap, this study explored the bidirectional mediation effects of social participation between functional limitations and cognitive functioning among a nationally representative sample of middle-aged and older adults in China.

Method

Research Design

The data utilised in this study were obtained from the China Health and Retirement Longitudinal Study (CHARLS), a nationally representative survey conducted across 28 provinces, 150 counties, and 450 communities in China (Zhao et al., 2014). The survey comprised multiple waves, including the baseline survey (T1 = Wave 1) conducted in 2011, followed by subsequent surveys in 2013 (T2 = Wave 2), 2015 (T3 = Wave 3), and 2018 (T4 = Wave 4). CHARLS is a publicly accessible database established by the National School of Development at Peking University. The CHARLS study was ethically reviewed and approved by the Ethical Review Committee of Peking University (Ref: IRB00001052-11015). All respondents provided their informed consent prior to participation. Further information about CHARLS can be found elsewhere (https://charls.pku.edu.cn). Since the

CHARLS dataset is completely anonymised, ethical approval from the authors' institution is exempted for the present study.

The initial sample size in CHARLS was 25,586. Given that ADL data were not collected from individuals under 50 years old, we restricted our sample to those aged 50 years and above at T1. Therefore, the final analytical sample comprised 16,385 respondents.

Measures

Functional Limitations. Functional limitations were measured using the Katz ADL scale (Katz et al., 1963) and the Lawton IADL scale (Lawton & Brody, 1969). The Katz ADL scale included dressing, bathing, eating, getting into or out of bed, and using the bathroom. Notably, CHARLS incorporated an additional ADL item—controlling urination and defecation. The Lawton IADL scale included doing household chores, preparing meals, shopping, making phone calls, taking medications, and managing money. The IADL item—making telephone calls was not available at T1, and this item was excluded due to incomparability in subsequent waves. Respondents rated each ADL and IADL using a 4-point Likert scale: (1) no, I don't have any difficulty; (2) I have difficulty but can still do it; (3) yes, I have difficulty and need help; (4) I cannot do it. Previous studies have indicated that ADL and IADL items can be combined to offer a valid score of functional limitations (e.g., Spector & Fleishman, 1998). Therefore, a total score ranging from 11 to 44 was calculated, with a higher score indicating more functional limitations. The Cronbach's alpha for the Katz ADL scale across all waves ranged from 0.836 to 0.866, while for the Lawton IADL scale, it ranged from 0.832 to 0.850 at all time points.

Social Participation. In CHARLS, the health status and function module included a question asking respondents whether they had participated in the following activities in the past month: (1) volunteer/charity work; (2) caring for a sick or disabled adult who does not live with the respondent and does not pay for the help; (3) providing help to family, friends, or neighbours who do not live with the respondent and do not pay for the help; (4) attending an educational or training course; (5) interacting with friends; (6) playing Mah-jong, chess, or cards, or going to a community club; (7) attending a sporting event or other kind of club; (8) taking part in a community-related organisation; (9) investing in stocks; and (10) surfing the Internet. These items were coded as binary: (0) no and (1) yes. Out of the 10 items, activities 2, 9 and 10 are not considered SAs. Additionally, activity 3 is likely to be interpreted as providing financial support to family and friends, which is not regarded as a social activity in the Chinese context (Hu et al., 2012). Therefore, we recoded the binary responses of activities 1, 3, 4, 5, 6, 7 and 8 into a single binary variable (0 = no, 1 = yes) to indicate whether the respondents had participated in at least one SA (for a similar approach, see Lestari et al., 2021).

Cognitive Functioning. Cognitive functioning was assessed using components from the Telephone Interview of Cognitive Status, which is similar to the cognition data module in the U.S. Health and Retirement Study (Brandt et al., 1988; Crimmins et al., 2011). The cognitive battery comprised two general factors: (1) memory functioning and (2) mental status (McArdle et al., 2007). Memory functioning was evaluated by immediate and delayed recall of a 10-item word list, scoring 1 point per item, for a total of 20 points. Mental status was assessed through orientation and executive functions. Orientation scored 1 point each for correctly stating the current day, month, year, and day of the week, totalling 4 points. Executive function was measured using two tasks: serial seven subtractions from 100 (5 trials, 0 = incorrect, 1 = correct) and a drawing task with overlapping pentagons (0 = incorrect, 1 = correct). The total score for these assessments ranged from 0 to 32, with higher values indicating better cognitive functioning. This assessment has been validated in the Chinese population (Meng et al., 2019).

Covariates. We adjusted for time-invariant covariates measured at T1, including age, gender (male, female), residence (urban, rural), and education level (≤lower secondary, upper secondary & vocational training, ≥tertiary). Additionally, socio-health demographic factors that are known to be associated with cognitive functioning and/or functional abilities were included as covariates, such as smoking status (never, former, current), and the frequency of alcohol consumption over the past year (never, ≤1 per month, 1-3 per month, 1-6 per week, ≥1 per day). Furthermore, we incorporated doctor-diagnosed chronic diseases (no, yes), including heart disease, stroke, hypertension, dyslipidaemia, diabetes, and memory-related diseases. Considering that obesity is associated with prospective cognitive declines (e.g., Whitmer et al., 2005), we further controlled for BMI, categorised by the cutoffs for the Chinese population (underweight, normal, overweight, obesity). In addition, participants' depressive symptoms (no, yes) were evaluated using the 10-item Centre for Epidemiological Studies Depression (CES-D) Scale, which has demonstrated good validity and reliability in the Chinese older population (Chen & Mui, 2014; Radloff, 1977). A cutoff score of 12 was used to indicate probable depression, as recommended for detecting depression in older adults (Lewinsohn et al., 1997). The Cronbach's alpha for the CES-D scale in CHARLS was 0.809.

Data Analyses

Data preparation and descriptive analyses were conducted using IBM SPSS version 29 (IBM Corp, 2022). First, we explored the patterns of missing data. The mean proportions of missing data per wave for functional limitations, social participation, and cognitive functioning were 41.80%, 24.03%, and 45.35%, respectively. To determine whether the missing data were missing completely at random (MCAR), we performed Little's MCAR test (Little, 1988). The result indicated that the data were not MCAR, with $\chi^2 = 45307.712$ and $p < 0.001$, suggesting that a complete case analysis is likely to introduce bias (Jakobsen et al., 2017). Considering the substantial amount of missing data, we performed multiple imputations using Mplus version 8.3 (Muthén & Muthén, 2017), replicating 5 datasets to impute the missing values, and included age and gender as auxiliary variables.

To examine the bidirectional mediation effects of social participation between functional limitations and cognitive functioning, whilst controlling for time-invariant covariates, a cross-lagged panel model (CLPM) was utilised. The CLPM was performed on each of the imputed data sets, and the results were pooled using Rubin's rule (Rubin, 1987). Considering the parsimony of the model, we followed the suggestion of Orth et al. (2021) to impose equality constraints on the autoregressive and cross-lagged paths across time points. Comparative fit index (CFI) values greater than 0.90 and 0.95, and root-mean-squared error of approximation (RMSEA) values below 0.08 and 0.05, respectively, were considered indicative of acceptable and good model fit (Kline, 2005). The estimation of the indirect paths of social participation was computed with 1,000 bootstrapping samples.

Results

The analytical sample consisted of 16,385 CHARLS respondents. The mean age at T1 (2011) was 62.188 (*SD* = 8.599). Approximately half of the respondents were female (50.1%), with the majority (59.2%) living in rural areas in China. Moreover, most participants had only received lower secondary education (87.8%). Approximately half of the participants had participated in at least one SA in T1 (45.7%), T2 (51.5%), T3 (46.0%), and T4 (41.8%). The mean scores for the sample from T1 to T4 were as follows: for functional limitations, 13.597 (*SD* = 4.471), 13.605 (*SD* = 4.624), 14.076 (*SD* = 5.048), and 14.760 (*SD* = 5.750); and for cognitive functioning, 15.286 (*SD* = 5.311), 15.443 (*SD* = 5.418), 14.482 (*SD* = 5.632), and 14.063 (*SD* = 6.219), respectively. Further descriptive statistics were presented in Table 1.

[Insert Table 1 and Table 2 about here]

As shown in Table 2, correlations between study variables were all significant at $p < 0.001$. Functional limitations were negatively correlated with social participation and cognitive functioning at any given time point. In contrast, social participation was positively correlated with cognitive functioning at any given time point.

[Insert Figure 1 about here]

Overall, the model indicated an adequate fit of the data, $\chi^2(45) = 4836.649$, $p < 0.001$, CFI = 0.928, RMSEA = 0.081. The standardised path coefficients of autoregressive and cross-lagged effects of the CLPM were presented in Figure 1. All autoregressive paths were found to be positive and significant at $p < 0.001$: the paths from functional limitations at T (i.e., a given time point) to functional limitations at T+1 ($\beta = 0.712$ to $\beta = 0.665$), from social participation at T to social participation at T+1 ($\beta = 0.457$ to $\beta = 0.525$), and from cognitive functioning at T to cognitive functioning at T+1 ($\beta = 0.730$ to $\beta = 0.665$). Bidirectional associations were observed between functional limitations and social participation, with more functional limitations at T predicted a decreased likelihood of social participation at T+1 ($\beta = -0.065$ to $\beta = -0.073$, $p < 0.001$), and vice versa ($\beta = -0.033$ to $\beta = -0.032$, $p < 0.001$). Functional limitations at T also predicted worse cognitive functioning at T+1 ($\beta = -0.051$ to $\beta = -0.050$, $p < 0.001$), whilst higher cognitive functioning predicted fewer functional limitations ($\beta = -0.079$ to $\beta = -0.068$, $p < 0.001$). Additionally, social participation predicted better cognitive functioning at T+1 ($\beta = 0.024$ to $\beta = 0.024$, $p < 0.01$), and vice versa ($\beta = 0.081$ to $\beta = 0.084$, $p < 0.001$).

[Insert Table 3 about here]

With significant cross-lagged effects observed between functional limitations, SA, and cognitive functioning, the hypothesised bidirectional mediating role of SA was investigated (see Table 3). The results indicated significant indirect effects of social participation between functional limitations at T1 and cognitive functioning at T3 (β = -

0.002, $p < 0.01$), and between functional limitations at T2 and cognitive functioning at T4 (β = -0.002, $p < 0.01$). Additionally, significant indirect effects of social participation were observed from cognitive functioning at T1 to functional limitations at T3 (β = -0.003, $p <$ 0.001), and from cognitive functioning at T2 to functional limitations at T4 (β = -0.003, $p <$ 0.001).

Discussion

The present study aimed to investigate the bidirectional mediation effects of social participation on the longitudinal relationship between functional limitations and cognitive functioning. Our findings align with broader literature indicating a bidirectional relationship between functional abilities and cognitive functioning (e.g., Martin et al., 2023), where functional limitations predict lower cognitive functioning, which in turn predicts further functional decline. According to the Disablement Process Framework, without timely intervention, functional limitations likely progress to severe disability, highlighting the need for timely interventions to mitigate the reinforcing mechanisms between functional limitations and cognitive decline.

A novel finding of this study suggests a reinforcing mechanism between functional limitations and cognitive decline, wherein social participation bidirectionally mediated this association: the onset of functional limitations predicted a lack of social participation, which predicted subsequent cognitive declines, and vice versa. This finding aligns with the notion that the onset of functional limitations may lead to social withdrawal for various reasons, such as prioritising health-related behaviours over social engagement (Fingerman et al., 2021). Likewise, those experiencing cognitive decline may devote greater effort to perform IADLs, resulting in fewer social interactions (Rotenberg et al., 2020). However, previous studies have indicated that older adults who withdraw from social participation are more prone to possess negative beliefs about social interactions, which further intensifies the risks of suffering from physiological and mental problems (Sánchez Palacios et al., 2009). On the other hand, older adults who are socially active are less susceptible to the detrimental effects of age stereotypes on cognitive functioning (Chan et al., 2020). As individuals with functional limitations are less likely to participate in SA, they become more vulnerable to cognitive decline. The poor cognitive performance could also be partly attributed by a withdrawing effort effect, that is, older adults with functional limitations may possess more negative beliefs about their social and cognitive ability, which demotivate them to take efforts in the cognitive assessment (Jamieson & Harkins, 2012). This may create a negative feedback loop, where lower cognitive functioning further contributes to functional limitations, thereby limiting their engagement in SA.

Social participation thus holds the promise of mitigating this negative feedback loop between the onset of functional limitations and cognitive decline, which is consistent with the Stress-Buffering Hypothesis. Functional limitations and cognitive decline can be significant life stressors due to their restrictions on daily activities (Pearlin & Skaff, 1996). Given that stressful events activate the HPA and SNS, they can further contribute to cognitive decline, which in turn affects functional ability, and vice versa. Extensive evidence has demonstrated the detrimental effects of stress on cognitive functioning (Lupien et al., 2009), and that cognitive decline can further contribute to functional decline (Sun et al., 2022). On the other hand, social participation provides opportunities to form social networks and to acquire adequate social support to buffer against stress (Li et al., 2018). Furthermore, participation in SAs can help individuals fulfil meaningful social roles, maintain and support their self-efficacy, and enhance their self-appraisal, where these psychological benefits could translate into better cognitive functioning (Paiva et al., 2023). Along these lines, the benefits of social participation have also been recognised as a protective factor against functional decline (Tomioka et al., 2016). Altogether, this suggests that social participation play an important role in intervening in the disablement process, highlighting the potential utility of interventions targeting social participation for those who have an early onset of functional limitations or cognitive decline.

Implications and Limitations of the Study

Given that social participation plays a crucial role in intervening in the disablement process, person-centred interventions that support social participation are vital for facilitating both physical and cognitive functioning. A holistic approach to healthcare, known as social prescribing, involves multidisciplinary professionals directing clients towards existing social engagement opportunities in their community to reduce loneliness and address psychological needs (Johansson et al., 2021). The National Health Service (NHS) in the UK first implemented the social prescribing initiative to address depression and loneliness, and it has since been integrated into the NHS long-term plan as part of its comprehensive care model (Alderwick & Dixon, 2019). A recent meta-review has shown encouraging outcomes among studies that included group-based social activities, support groups with educational elements, recreational activities, and the use of communication technologies (Paquet et al., 2023). Despite the emerging evidence supporting social prescribing, the integration of social and medical care for older adults in China remains a relatively novel concept (Menhas et al., 2023). Thus, more efforts are required to promote the social prescribing model and perform rigorous, high-quality studies using social prescribing in the Chinese context.

The significant bidirectional mediation between functional limitations and cognitive decline suggests that more efforts should be placed to target these vulnerable individuals at an early stage to foster social inclusion. Considering the physical and cognitive restrictions experienced by these individuals, engaging in low cognitive/physical intensity social activities may also be an effective way to enhance social connections, which exert protective effects against neuropathy. For example, Mortimer et al. (2012) investigated the impact of group Tai Chi, walking, and social interaction on the neuropsychological health of older adults, suggesting that social engagement can enhance cognitive function and increase brain volumes. To further promote social participation, it is also essential for governments to increase social campaigns to advertise the social prescribing model of healthcare, as well as public awareness about the health and cognitive benefits of SAs. This should be further complemented by environmental support, such as promoting an age-friendly living environment that accommodates the needs of older adults in social participation (Evans et al., 2018).

A strength of this study could be our novel investigation of the psychosocial mechanisms within the bidirectional and reciprocal relationship between functional limitations and cognitive decline. We provide longitudinal evidence using a large, representative Chinese sample from CHARLS. Furthermore, we controlled for the effects of other confounding variables on functional abilities and cognitive functioning, including socio-health-demographic factors such as age, gender, education, residential status, smoking status, frequency of alcohol consumption, chronic disease status, BMI, and probable depression. This suggests a unique contribution of social participation in this association. However, there are also limitations to this study. For example, the list of SAs in CHARLS was not exhaustive, and respondents may have engaged in other activities, such as attending religious groups. Furthermore, the results may be less generalisable to other countries because the effect of SAs can vary between cultural contexts, which warrants further exploration in Western contexts. Additionally, we did not explore the diversity of participation in SAs, where participating in multiple types of activities may have additional benefits (Xie & Ma, 2021). Nonetheless, our findings, consistent with other Western studies (e.g., Fernández et al., 2023), found a generally positive effect of social participation, emphasising its universal health and cognitive benefits.

Conclusion

Our study provides longitudinal evidence of the bidirectional and reciprocal relationship between the onset of functional limitations and subsequent cognitive declines. Importantly, social participation bidirectionally mediated this relationship, in that individuals with higher functional limitations may withdraw from social participation, leading to lower levels of cognitive functioning, and vice versa. Therefore, social participation can play a significant role in mitigating the reinforcing mechanism between functional limitations and cognitive functioning, contributing to a more successful ageing experience.

References

Alderwick, H., & Dixon, J. (2019). The NHS long term plan. *BMJ*, *364*, l84. https://doi.org/10.1136/bmj.l84

Brandt, J., Spencer, M., & Folstein, M. F. (1988). The Telephone Interview for Cognitive Status. *Neuropsychiatry, Neuropsychology, & Behavioral Neurology*, *1*(2), 111-17.

Brown, R. T., Diaz-Ramirez, L. G., Boscardin, W. J., Lee, S. J., Williams, B. A., & Steinman, M. A. (2019). Association of Functional Impairment in Middle Age With Hospitalization, Nursing Home Admission, and Death. *JAMA Intern Med*, *179*(5), 668-75. https://doi.org/10.1001/jamainternmed.2019.0008

Burdick, D. J., Rosenblatt, A., Samus, Q. M., Steele, C., Baker, A., Harper, M., Mayer, L., Brandt, J., Rabins, P., & Lyketsos, C. G. (2005). Predictors of functional impairment in residents of assisted-living facilities: the Maryland Assisted Living study. *J Gerontol A Biol Sci Med Sci*, *60*(2), 258-64. https://doi.org/10.1093/gerona/60.2.258

Chan, S. C. Y., Au, A. M. L., & Lai, S. M. K. (2020). The detrimental impacts of negative age stereotypes on the episodic memory of older adults: does social participation moderate the effects? *BMC Geriatrics*, *20*(1), 452. https://doi.org/10.1186/s12877-020-01833-z

Chen, H., & Mui, A. C. (2014). Factorial validity of the Center for Epidemiologic Studies Depression Scale short form in older population in China. *Int Psychogeriatr*, *26*(1), 49-57. https://doi.org/10.1017/s1041610213001701

Cohen, S., & Wills, T. A. (1985). Stress, social support, and the buffering hypothesis. *Psychological Bulletin*, *98*(2), 310-57. https://doi.org/10.1037/0033-2909.98.2.310

Crimmins, E. M., Kim, J. K., Langa, K. M., & Weir, D. R. (2011). Assessment of Cognition Using Surveys and Neuropsychological Assessment: The Health and Retirement Study and the Aging, Demographics, and Memory Study. *The Journals of*

Gerontology: Series B, *66B*(suppl_1), i162-i71. https://doi.org/10.1093/geronb/gbr048

Dombrowsky, T. A. (2017). Relationship between engagement and level of functional status in older adults. *SAGE Open Med*, *5*, 2050312117727998. https://doi.org/10.1177/2050312117727998

Evans, I. E. M., Llewellyn, D. J., Matthews, F. E., Woods, R. T., Brayne, C., Clare, L., & on behalf of the, C.-W. r. t. (2018). Social isolation, cognitive reserve, and cognition in healthy older people. *PLoS One*, *13*(8), e0201008. https://doi.org/10.1371/journal.pone.0201008

Farias, S. T., Lau, K., Harvey, D., Denny, K. G., Barba, C., & Mefford, A. N. (2017). Early Functional Limitations in Cognitively Normal Older Adults Predict Diagnostic Conversion to Mild Cognitive Impairment. *J Am Geriatr Soc*, *65*(6), 1152-58. https://doi.org/10.1111/jgs.14835

Fernández, I., García-Mollá, A., Oliver, A., Sansó, N., & Tomás, J. M. (2023). The role of social and intellectual activity participation in older adults' cognitive function. *Archives of Gerontology and Geriatrics*, *107*, 104891. https://doi.org/https://doi.org/10.1016/j.archger.2022.104891

Fingerman, K. L., Ng, Y. T., Huo, M., Birditt, K. S., Charles, S. T., & Zarit, S. (2021). Functional Limitations, Social Integration, and Daily Activities in Late Life. *J Gerontol B Psychol Sci Soc Sci*, *76*(10), 1937-47. https://doi.org/10.1093/geronb/gbab014

Hu, D., Wu, Y., Zhu, J., Zhu, Y., & Chen, J. (2021). Age-Related Disease Burden in China, 1997–2017: Findings From the Global Burden of Disease Study. *Frontiers in Public Health*. https://doi.org/10.3389/fpubh.2021.638704

Hu, Y., Lei, X., Smith, J. P., & Zhao, Y. (2012). Effects of social activities on cognitive functions: Evidence from CHARLS. In J. P. Smith & M. Majmundar (Eds.), *Aging in Asia: Findings from new and emerging data initiatives* (pp. 12). National Academies Press. https://www.ncbi.nlm.nih.gov/books/NBK109224/

Hwang, Y., Massimo, L., Aryal, S., & Hodgson, N. A. (2022). The relationship between social isolation and anxiety in people with cognitive impairment in the United States. *Int J Geriatr Psychiatry*, *37*(2). https://doi.org/10.1002/gps.5679

IBM Corp. (2022). *IBM SPSS Statistics for Windows, Version 29.0*. IBM Corp.

Jakobsen, J. C., Gluud, C., Wetterslev, J., & Winkel, P. (2017). When and how should multiple imputation be used for handling missing data in randomised clinical trials – a practical guide with flowcharts. *BMC Medical Research Methodology*, *17*(1), 162. https://doi.org/10.1186/s12874-017-0442-1

Jamieson, J. P., & Harkins, S. G. (2012). Distinguishing between the effects of stereotype priming and stereotype threat on math performance. *Group Processes & Intergroup Relations*, *15*(3), 291-304. https://doi.org/10.1177/1368430211417833

Johansson, E., Jonsson, F., Rapo, E., Lundgren, A. S., Hörnsten, Å., & Nilsson, I. (2021). Let's Try Social Prescribing in Sweden (SPiS) - an Interventional Project Targeting Loneliness among Older Adults Using a Model for Integrated Care: A Research Protocol. *Int J Integr Care*, *21*(2), 33. https://doi.org/10.5334/ijic.5609

Katz, S., Ford, A. B., Moskowitz, R. W., Jackson, B. A., & Jaffe, M. W. (1963). Studies of Illness in the Aged: The Index of ADL: A Standardized Measure of Biological and Psychosocial Function. *JAMA*, *185*(12), 914-19. https://doi.org/10.1001/jama.1963.03060120024016

Kline, R. B. (2005). *Principles and practice of structural equation modeling, 2nd ed*. Guilford Press.

Kuiper, J. S., Zuidersma, M., Oude Voshaar, R. C., Zuidema, S. U., van den Heuvel, E. R., Stolk, R. P., & Smidt, N. (2015). Social relationships and risk of dementia: A systematic review and meta-analysis of longitudinal cohort studies. *Ageing Res Rev*, *22*, 39-57. https://doi.org/10.1016/j.arr.2015.04.006

Lawton, M. P., & Brody, E. M. (1969). Assessment of older people: self-maintaining and instrumental activities of daily living. *Gerontologist*, *9*(3), 179-86.

Lestari, S. K., de Luna, X., Eriksson, M., Malmberg, G., & Ng, N. (2021). A longitudinal study on social support, social participation, and older Europeans' Quality of life. *SSM - Population Health*, *13*, 100747. https://doi.org/https://doi.org/10.1016/j.ssmph.2021.100747

Lewinsohn, P. M., Seeley, J. R., Roberts, R. E., & Allen, N. B. (1997). Center for Epidemiologic Studies Depression Scale (CES-D) as a screening instrument for depression among community-residing older adults. *Psychol Aging*, *12*(2), 277-87. https://doi.org/10.1037//0882-7974.12.2.277

Li, C., Jiang, S., Li, N., & Zhang, Q. (2018). Influence of social participation on life satisfaction and depression among Chinese elderly: Social support as a mediator. *Journal of Community Psychology*, *46*(3), 345-55. https://doi.org/https://doi.org/10.1002/jcop.21944

Lin, S. L. (2023). Functional Disability Among Middle-Aged and Older Adults in China: The Intersecting Roles of Ethnicity, Social Class, and Urban/Rural Residency. *Int J Aging Hum Dev*, *96*(3), 350-75. https://doi.org/10.1177/00914150221092129

Little, R. J. A. (1988). A Test of Missing Completely at Random for Multivariate Data with Missing Values. *Journal of the American Statistical Association*, *83*(404), 1198-202. https://doi.org/10.1080/01621459.1988.10478722

Lupien, S. J., McEwen, B. S., Gunnar, M. R., & Heim, C. (2009). Effects of stress throughout the lifespan on the brain, behaviour and cognition. *Nat Rev Neurosci*, *10*(6), 434-45. https://doi.org/10.1038/nrn2639

Martin, P., Poon, L. W., Lee, G., Obhi, H. K., Kallianpur, K. J., Willcox, B., & Masaki, K. (2023). A 13-Year Time-Lagged Description of General Cognitive and Functional Abilities in Older Men: A Cross-Lagged Panel Model. *J Aging Health*, *35*(5-6), 335-44. https://doi.org/10.1177/08982643221130381

McArdle, J. J., Fisher, G. G., & Kadlec, K. M. (2007). Latent variable analyses of age trends of cognition in the Health and Retirement Study, 1992-2004. *Psychol Aging*, *22*(3), 525-45. https://doi.org/10.1037/0882-7974.22.3.525

Meng, Q., Wang, H., Strauss, J., Langa, K. M., Chen, X., Wang, M., Qu, Q., Chen, W., Kuang, W., Zhang, N., Li, T., Wang, Y., & Zhao, Y. (2019). Validation of neuropsychological tests for the China Health and Retirement Longitudinal Study Harmonized Cognitive Assessment Protocol. *Int Psychogeriatr*, *31*(12), 1709-19. https://doi.org/10.1017/s1041610219000693

Menhas, R., Yang, L., & Danish Nisar, R. (2023). Community-based social healthcare practices in China for healthy aging: a social prescription perspective analysis. *Front Public Health*, *11*, 1252157. https://doi.org/10.3389/fpubh.2023.1252157

Mortimer, J. A., Ding, D., Borenstein, A. R., DeCarli, C., Guo, Q., Wu, Y., Zhao, Q., & 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), 757-66. https://doi.org/10.3233/jad-2012-120079

Muthén, L. K., & Muthén, B. O. (2017). *Mplus: Statistical Analysis with Latent Variables: User's Guide (Version 8)*. Authors.

Nichols, L. O., Martindale-Adams, J., Greene, W. A., Burns, R., Graney, M. J., & Lummus, A. (2008). Dementia Caregivers' Most Pressing Concerns. *Clinical Gerontologist*, *32*(1), 1-14. https://doi.org/10.1080/07317110802468546

Orth, U., Clark, D. A., Donnellan, M. B., & Robins, R. W. (2021). Testing prospective effects in longitudinal research: Comparing seven competing cross-lagged models. *J Pers Soc Psychol*, *120*(4), 1013-34. https://doi.org/10.1037/pspp0000358

Paiva, A. F., Cunha, C., Voss, G., & Delerue Matos, A. (2023). The interrelationship between social connectedness and social engagement and its relation with cognition: a study using SHARE data. *Ageing and Society*, *43*(8), 1735-53. https://doi.org/10.1017/S0144686X2100129X

Paquet, C., Whitehead, J., Shah, R., Adams, A. M., Dooley, D., Spreng, R. N., Aunio, A. L., & Dubé, L. (2023). Social Prescription Interventions Addressing Social Isolation and Loneliness in Older Adults: Meta-Review Integrating On-the-Ground Resources. *J Med Internet Res*, *25*, e40213. https://doi.org/10.2196/40213

Pearlin, L. I., & Skaff, M. M. (1996). Stress and the life course: a paradigmatic alliance. *Gerontologist*, *36*(2), 239-47. https://doi.org/10.1093/geront/36.2.239

Radloff, L. S. (1977). The CES-D Scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement*, *1*(3), 385-401. https://doi.org/10.1177/014662167700100306

Rosso, A. L., Taylor, J. A., Tabb, L. P., & Michael, Y. L. (2013). Mobility, disability, and social engagement in older adults. *J Aging Health*, *25*(4), 617-37. https://doi.org/10.1177/0898264313482489

Rotenberg, S., Maeir, A., & Dawson, D. R. (2020). Changes in Activity Participation Among Older Adults With Subjective Cognitive Decline or Objective Cognitive Deficits

[Original Research]. *Frontiers in Neurology*, *10*. https://doi.org/10.3389/fneur.2019.01393

Royall, D. R., Palmer, R., Chiodo, L. K., & Polk, M. J. (2004). Declining executive control in normal aging predicts change in functional status: the Freedom House Study. *J Am Geriatr Soc*, *52*(3), 346-52. https://doi.org/10.1111/j.1532-5415.2004.52104.x

Rubin, D. B. (1987). *Multiple imputation for nonresponse in surveys*. John Wiley & Sons, Inc.

Sánchez Palacios, C., Trianes Torres, M. V., & Blanca Mena, M. J. (2009). Negative aging stereotypes and their relation with psychosocial variables in the elderly population. *Archives of Gerontology and Geriatrics*, *48*(3), 385-90. https://doi.org/10.1016/j.archger.2008.03.007

Seeman, T. E., & McEwen, B. S. (1996). Impact of social environment characteristics on neuroendocrine regulation. *Psychosom Med*, *58*(5), 459-71. https://doi.org/10.1097/00006842-199609000-00008

Spector, W. D., & Fleishman, J. A. (1998). Combining Activities of Daily Living with Instrumental Activities of Daily Living to Measure Functional Disability. *The Journals of Gerontology: Series B*, *53B*(1), S46-S57. https://doi.org/10.1093/geronb/53B.1.S46

Sun, Q., Jiang, N., Lu, N., & Lou, V. W. Q. (2022). Bidirectional relationship between cognitive function and loss hierarchy of activities of daily living among older adults with disabilities in urban China: a cross-lagged analysis. *BMJ Open*, *12*(9), e057211. https://doi.org/10.1136/bmjopen-2021-057211

Tomioka, K., Kurumatani, N., & Hosoi, H. (2016). Relationship of Having Hobbies and a Purpose in Life With Mortality, Activities of Daily Living, and Instrumental

Activities of Daily Living Among Community-Dwelling Elderly Adults. *J Epidemiol*, *26*(7), 361-70. https://doi.org/10.2188/jea.JE20150153

Verbrugge, L. M., & Jette, A. M. (1994). The disablement process. *Soc Sci Med*, *38*(1), 1-14. https://doi.org/10.1016/0277-9536(94)90294-1

Whitmer, R. A., Gunderson, E. P., Barrett-Connor, E., Quesenberry, C. P., Jr., & Yaffe, K. (2005). Obesity in middle age and future risk of dementia: a 27 year longitudinal population based study. *BMJ*, *330*(7504), 1360. https://doi.org/10.1136/bmj.38446.466238.E0

Wróblewska, I., Zborowska, I., Dąbek, A., Susło, R., Wróblewska, Z., & Drobnik, J. (2018). Health Status, Health Behaviors, and the Ability to Perform Everyday Activities in Poles Aged &Amp;ge;65 Years Staying in Their Home Environment. *Clinical interventions in aging*. https://doi.org/10.2147/cia.s152456

Xie, B., & Ma, C. (2021). Effect of social participation on the development of physical frailty: Do type, frequency and diversity matter? *Maturitas*, *151*, 48-54. https://doi.org/https://doi.org/10.1016/j.maturitas.2021.06.015

Yang, R., Wang, H., Edelman, L. S., Tracy, E. L., Demiris, G., Sward, K. A., & Donaldson, G. W. (2020). Loneliness as a mediator of the impact of social isolation on cognitive functioning of Chinese older adults. *Age Ageing*, *49*(4), 599-604. https://doi.org/10.1093/ageing/afaa020

Tables and Figures

TABLE 1. Descriptive statistics for covariates and study variables (*N* = 16,385)

	M (*SD*)/%
Age	62.188 (8.599)
Female	50.1%
Rural residence	59.2%
Education level	
Lower secondary	87.8%
Upper secondary & vocational training	10.0%
Tertiary	2.1%
Smoking status	
Never	59.6%
Former	12.5%
Current	28.0%
Frequency of alcohol consumption over the past year	
Never	73.3%
Less than 1 per month	7.8%
1-3 per month	3.2%
1-6 per week	4.7%
More than 1 per day	10.9%
Body Mass Index	
Underweight	7.3%
Normal	42.2%
Overweight	20.2%
Obesity	30.4%
Diagnosed with chronic diseases	53.5%
Probable depression	46.5%
Functional limitations (1-44)	
T1	13.597 (4.471)
T2	13.605 (4.624)
T3	14.076 (5.048)
T4	14.760 (5.750)
Social participation (participated in at least 1 social activity)	
T1	45.7%
T2	51.5%
T3	46.0%
T4	41.8%
Cognitive functioning (0-32)	
T1	15.286 (5.311)
T2	15.443 (5.418)
T3	14.482 (5.632)
T4	14.063 (6.219)

Note. T1 = 2011, T2 = 2013, T3 = 2015, T4 = 2018.

TABLE 2. Correlation matrix between study variables

Variables	1	2	3	4	5	6	7	8	9	10	11
1. FL_T1											
2. FL_T2	0.577[a]										
3. FL_T3	0.540[a]	0.687[a]									
4. FL_T4	0.486[a]	0.608[a]	0.683[a]								
5. SP_T1	-0.146[b]	-0.125[b]	-0.123[b]	-0.116[b]							
6. SP_T2	-0.136[b]	-0.187[b]	-0.145[b]	-0.138[b]	0.413[c]						
7. SP_T3	-0.125[b]	-0.149[b]	-0.174[b]	-0.164[b]	0.405[c]	0.454[c]					
8. SP_T4	-0.147[b]	-0.152[b]	-0.191[b]	-0.240[b]	0.339[c]	0.404[c]	0.460[c]				
9. COG_T1	-0.247[a]	-0.209[a]	-0.226[a]	-0.241[a]	0.188[b]	0.204[b]	0.202[b]	0.199[b]			
10. COG_T2	-0.193[a]	-0.229[a]	-0.243[a]	-0.242[a]	0.161[b]	0.227[b]	0.200[b]	0.185[b]	0.599[a]		
11. COG_T3	-0.189[a]	-0.238[a]	-0.274[a]	-0.283[a]	0.147[b]	0.212[b]	0.224[b]	0.203[b]	0.613[a]	0.651[a]	
11. COG_T4	-0.162[a]	-0.228[a]	-0.260[a]	-0.319[a]	0.130[b]	0.178[b]	0.200[b]	0.205[b]	0.582[a]	0.619[a]	0.673[a]

Note. COG = cognitive functioning, FL = functional limitations, SP = social participation, T1 = 2011, T2 = 2013, T3 = 2015, T4 = 2018.

FL and COG ranged from 1 to 44 and 0 to 32, respectively.

SP was coded as 0 (did not participate in any social activities) and 1 (participated in at least one social activity).

All correlations coefficients ([a]Pearson, [b]point-biserial, [c]tetrachoric) were significant at $p < 0.001$.

TABLE 3. Standardised path coefficients of mediation effects of the CLPM

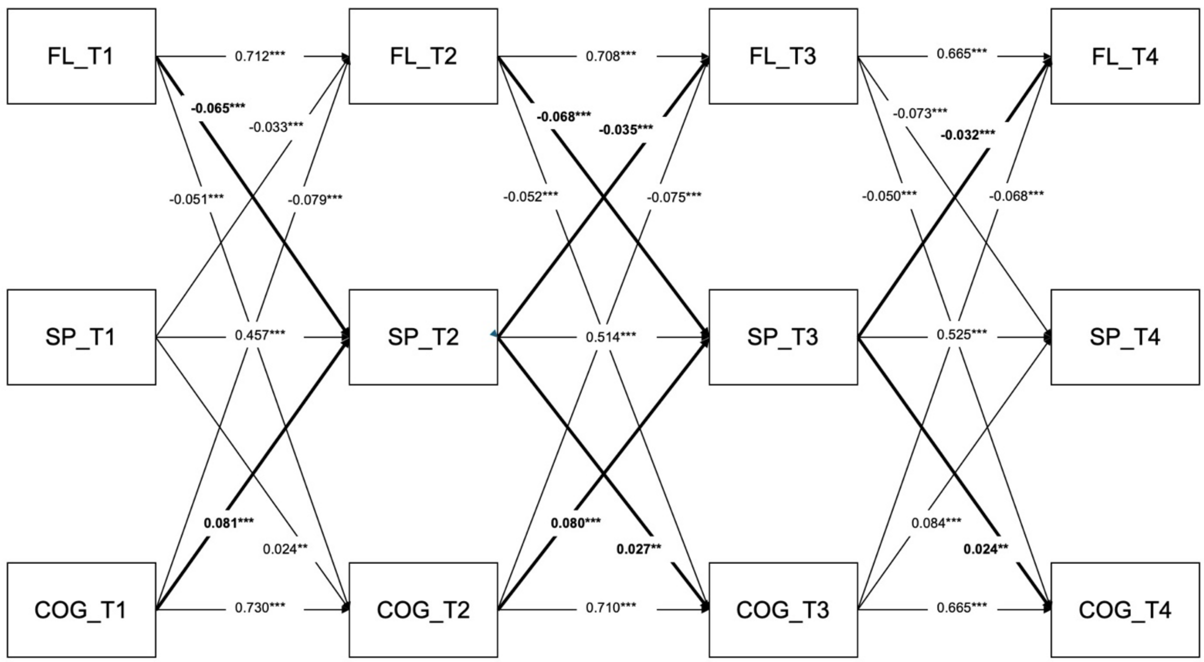
	β	*SE*	95% CI	*p*
Effect of IV on M (*a*)				
FL_T1 → SP_T2	-0.065	0.008	-0.081, -0.049	<0.001
FL_T2 → SP_T3	-0.068	0.008	-0.084, -0.051	<0.001
COG_T1 → SP_T2	0.081	0.009	0.063, 0.098	<0.001
COG_T2 → SP_T3	0.080	0.009	0.062, 0.098	<0.001
Effect of M on DV (*b*)				
SP_T2 → COG_T3	0.027	0.008	0.010, 0.043	<0.01
SP_T3 → COG_T4	0.024	0.008	0.009, 0.039	<0.01
SP_T2 → FL_T3	-0.035	0.009	-0.053, -0.018	<0.001
SP_T3 → FL_T4	-0.032	0.008	-0.047, -0.016	<0.001
Direct effect (*c'*)				
FL_T1 → COG_T3	-0.075	0.011	-0.097, -0.053	<0.001
FL_T2 → COG_T4	-0.072	0.011	-0.093, -0.051	<0.001
COG_T1 → FL_T3	-0.113	0.009	-0.131, -0.096	<0.001
COG_T2 → FL_T4	-0.101	0.008	-0.116, -0.085	<0.001
Indirect effect (*ab*)				
FL_T1 → SP_T2 → COG_T3	**-0.002**	**0.001**	**-0.003, -0.001**	**<0.01**
FL_T2 → SP_T3 → COG_T4	**-0.002**	**0.001**	**-0.003, -0.001**	**<0.01**
COG_T1 → SP_T2 → FL_T3	**-0.003**	**0.001**	**-0.004, -0.002**	**<0.001**
COG_T2 → SP_T3 → FL_T4	**-0.003**	**0.001**	**-0.004, -0.001**	**<0.001**

Note. CLPM = Cross-lagged panel model; COG = cognitive functioning; FL = functional limitations;

SP = social participation, T1 = 2011, T2 = 2013, T3 = 2015, T4 = 2018.

Bold indicates a significant indirect effect.

FIGURE 1. Standardised path coefficients of the CLPM



Note. CLPM = Cross-lagged panel analysis; COG = cognitive functioning; FL = functional limitation; SP = social participation , T1 = 2011, T2 = 2013, T3 = 2015, T4 = 2018.

Bold denotes mediation paths.

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$