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What impact does hearing impairment have on cognitive health in older married couples in China?

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Abstract:	Hearing impairment is a common geriatric health problem and chronic stressor, and it is associated with poor cognitive outcomes. However, little is known about the impact of hearing impairment in married couples, particularly its potential spillover effects on the cognitive health among spouses of individuals with impairment. Drawing on a stress-proliferation perspective, we used actor–partner interdependence models to examine (1) whether an individual's hearing impairment influences their spouse's cognitive function; and (2) whether AL, symptoms of depression, and social participation serve as mediators for such an association. We utilized data from the 2015 (baseline) and 2018 (3-year follow-up) waves of the China Health and Retirement Longitudinal Study. 4434 couples were included at baseline, and 2190 couples remained after the 3-year follow-up. Hearing impairment among married women were associated with negative impacts on their spouses' cognitive function. Symptoms of depression and social participation may have served as potential mediators in this relationship. For married men, there was no statistically significant association between hearing impairment and spouses' cognitive function. Our findings suggest that hearing impairment among one spouse can lead to negative impacts on the other, but that this effect may depend on gender. Early diagnosis and couple-based interventions for hearing impairment are important for the cognitive health of both hearing-impaired individuals and their spouses.

1. Introduction

Against the background of a rapidly ageing population, the prevalence of cognitive disorders in China is expected to soar. A recent nationwide survey estimated that more than a fifth of Chinese adults aged 60 or older had mild cognitive impairment (MCI) and dementia, with approximately 9.83 million patients in China suffering from Alzheimer's disease (AD) (L. Jia et al., 2020). AD contributes to a heavy disease burden with high economic costs in China, and the total annual AD-attributable cost has been estimated to be as high as US $1.89 trillion in 2050 (J. Jia et al., 2018). The increasing prevalence and burden of MCI and dementia make cognitive health a major public health concern. In particular, it is of critical importance to identify potential risk factors for cognitive impairment that can serve as intervention targets for prevention programs.

Recent evidence has demonstrated that hearing impairment may exacerbate risks of cognitive impairment and dementia (Loughrey et al., 2018). Hearing impairment has been identified as a key modifiable risk factor for cognitive impairment, as evidence suggests that eliminating midlife hearing loss may reduce dementia risk by an estimated 9.1% (Livingston et al., 2017). However, in spite of evidence indicating significant health implications of hearing impairment, it is commonly overlooked as a 'natural' part of aging and remains a neglected public health issue (Sloane et al., 2021). Understanding the complex relationship between hearing impairment and cognitive disorders could provide insights into potential joint interventions to alleviate the disease burden imposed by both and support advocacy efforts for addressing hearing impairment as a public health issue.

Perhaps a hitherto underappreciated problem is the role of hearing impairment in married couples. A previous systematic review indicated that an individual's hearing impairment may have negative spillover effects on the psychosocial and relational well-being of couples (Lehane et al., 2017). Due to the shared living environment, financial resources, and social network between partners in marriage, along with the direct negative impact on communication and interaction, hearing impairment may strain the couple relationship and potentially cause adverse health effects on the unimpaired spouse (Meyler et al., 2007; Wickrama et al., 2020). Given the fact that individuals in intimate relationships are not socially independent entities, it is high time to examine the health impacts of hearing impairment from a family systems perspective, taking into account potential spillover effects of hearing impairment in one spouse on another's wellbeing (Senn et al., 2023).

To the best of our knowledge, past investigation of connections between hearing impairment and cognitive function within married couples has been limited. Given current challenges in treating or managing cognitive decline and dementia, ascertaining risk factors for cognitive decline related to hearing impairment in families may provide new intervention targets for preventing cognitive decline. Therefore, our study examined the association between hearing impairment and cognitive function among middle-aged and older married couples in China.

2. Background

2.1 Stress Proliferation of Hearing Impairment within Marriage and Potential Mechanisms

Hearing impairment can be conceptualized as a health stressor affecting an individual's cognitive health. It can worsen chronic stress by directly hindering effective communication, posing significant challenges to the individual's sense of self and social identity, or exposing individuals to disability-related stigma (Barker et al., 2017). In turn, chronic stress can trigger the release of high levels of glucocorticoids, which can damage the structure of brain regions responsible for memory and impact cognition (Lupien et al., 2007). Moreover, hearing impairment is an important physical health stressor that can affect various health outcomes. For instance, it is associated with loneliness, social isolation, and depression, all of which are risk factors for cognitive impairment (Maharani et al., 2019; Wu & Zhou, 2024).

According to stress proliferation theory, health stressors have cross-person spillover effects, commonly when one person's well-being impacts the health of family members (Thoits, 2010). Given that hearing impairment is considered a health stressor, it may contribute to the proliferation of stress amongst spouses. Hearing impairment could also affect the ability of the couple to function as a unit and cope with various demands in the daily life of marriage (Bertschi et al., 2021). As a result of these accumulated stresses, hearing impairment in one individual might harm the cognitive health of their spouse.

We can classify pathways through which stress associated with one person's hearing impairment may harm the cognitive health to their spouse into two categories: physiological and psychosocial pathways. The physiological pathway involves allostatic load (AL) mediating a negative association between hearing impairment and spousal cognitive function. Research has revealed that married couples often exhibit concordance in various biomarkers, including AL (Chiu & Lin, 2019). Moreover, a previous study found a positive correlation between a decline in hearing function and increased AL among older Chinese adults (Yang & Luo, 2023). AL serves as an indicator of physiological dysregulation caused by chronic stressors and has been found to be positively associated with cognitive impairment (D'Amico et al., 2020; Juster et al., 2010). Taken together, these findings suggest that one person's hearing impairment may spill over to their spouse in the form of elevated AL, thus contributing to cognitive impairment.

The psychosocial pathway involves symptoms of depression and social participation playing a role. Evidence has shown a positive association between hearing impairment and risk of symptoms of depression (Huang et al., 2022). Theories of emotional contagion suggest that couples coping with chronic conditions such as hearing impairment may cause depressive symptoms in both members of the dyad (Monin et al., 2017). Moreover, individuals with hearing impairment may adopt avoidant coping strategies, including withdrawal from social activities and participation restrictions (Heffernan et al., 2016). This can have spillover effects on partners or spouses, as joint social activities become less frequent due to the partner's hearing difficulties (Scarinci et al., 2008). Given that higher levels of symptoms of depression and decreased social participation are risk factors for cognitive decline (Mehta et al., 2022; Sachdev, 2022), they may also plausibly mediate impacts of hearing impairment on cognitive function.

2.2 Hearing Impairment and Gender in Married Couples

Gender may modulate the impact of hearing impairment on cognitive health outcomes in married couples. Previous research has found the spillover effects of one person's health status on that of their spouse to differ by gender (Kiecolt-Glaser & Newton, 2001). This includes spill-over effects of hearing impairment on the physical, psychological, and social well-being of partners (Wallhagen et al., 2004).

Multiple possible reasons for gender differences in the impact of hearing impairment on cognitive impairment among married couples have been proposed. First, the burden of caring for a partner with hearing impairment may differ due to gender stereotypes and social norms. Women and men experience unequal caregiver burdens, as women are often socialized into roles as primary caregivers for family members after marriage, while men are not expected to take on similarly taxing caring roles (Ohu et al., 2019). When partners are in need of care, husbands could experience stress, frustration, and upset at having to assume an unanticipated role of spousal caregiver, a role that may seem incongruent to them with their default gender identity (Zygouri et al., 2021). A previous study found that caregiving burdens were positively associated with high AL, and AL appeared to be higher in male caregivers than in female caregivers (Dich et al., 2015). Moreover, previous research found that having married women with hearing impairment was associated with higher levels of symptoms of depression for husbands, whilst there was no evidence for an association between hearing impairment in husbands and symptoms of depression in their partners (West, 2021; West et al., 2023). These findings suggest that the negative impact on the husband's health of caring for a wife with hearing impairment on the husbands may be stronger than the reverse.

Second, the adverse effect of reduced interpersonal interaction and joint social activities on cognitive health caused by a partner's hearing impairment may vary by gender. In the intimate relationships, husbands tend to rely on their wives as confidants for emotional disclosure and support (Antonucci & Akiyama, 1987), whilst married women often have larger social networks and more external social sources of emotional and instrumental support than husbands (Sauter et al., 2022). Therefore, given that husbands may experience a more significant decrease in emotional support and social participation due to their partners' hearing difficulties compared to wives, the related negative impacts of on cognitive health could be greater as well.

2.3 The Current Status of Hearing Impairment and Challenges in Cognitive Impairment-Related Spousal Caregiving in China

In China, the vast majority of cases of hearing impairment remain unaddressed, despite their high prevalence and burden. Globally, hearing impairment has been estimated to affect about 2.45 billion people worldwide by 2050 (GBD 2019 Hearing Loss Collaborators, 2021). However, ear and hearing care are often under-prioritized in national health policies, especially in low- and middle-income countries (Canick et al., 2023). Global hearing aid coverage has been estimated to be around 11%, varying from 2% in the African region to 33% in the European region (Bisgaard et al., 2022). The Western Pacific region, in which China is located, has the largest number of people with moderate-to-profound hearing impairment, yet hearing aid coverage is only 7% (Bisgaard et al., 2022; GBD 2019 Hearing Loss Collaborators, 2021). The burden of hearing impairment amongst Chinese middle-aged and older people is expected to increase further given current demographic changes in China. Recent evidence suggests that nearly two-thirds of Chinese adults aged 60 years and older experience hearing decline, with 7.2% suffering from severe and extremely heavy hearing impairment (Gong et al., 2018). In China, it has been estimated that the direct costs attributable to hearing impairment in adults aged 45 and above accounted for 5.54% of the overall healthcare costs in 2015 (Ye & He, 2023). Meanwhile, the prevalence of hearing aid acquisition was low, reported to be only 6.5% among people with hearing impairment (He et al., 2018). In China, the hearing healthcare infrastructure remains underdeveloped, and hearing aids are not covered by medical insurance (F. Zhao et al., 2015). This situation poses significant challenges to the availability and affordability of hearing rehabilitation. Additionally, under the influence of traditional health beliefs such as ‘a cure for the root of the disease is better than symptomatic treatment', Chinese older adults commonly hold negative attitudes towards hearing aids, regarding them as a merely palliative rather than a cure (Zheng et al., 2023).

In the context of China, there is a need to develop interventions for cognitive impairment within a dyadic framework among couples. Due to rapid industrialization and urbanization processes, nuclear families are on the rise compared to extended families (Dong et al., 2023). This change in family structure cause crucial marital relationships to become the central axis of family relations, with spouses playing a critical role in caregiving responsibilities. In this situation, the burden of caring for partners with cognitive disorders is expected to increase as well. This greater burden for caregivers not only diminishes their well-being but also potentially serves as a risk factor for their own cognitive health (Dassel et al., 2017).

Therefore, the objective of this study was to examine the association between hearing impairment and cognitive function among Chinese married couples. The findings may have implications for dyadic coping strategies related to both cognitive health and hearing health, as well as for health policies related to ear and hearing care.

2.4 Study Aims

Drawing on a stress proliferation framework, we used data from a nationally representative sample of middle-aged and older married couples in China to investigate (1) whether an individual's hearing impairment influences their spouse's cognitive function; and (2) whether AL, symptoms of depression, and social participation serve as mediators for such an association.

3. Methods

3.1 Data and Study Sample

The data for this study were drawn from the China Health and Retirement Longitudinal Study (CHARLS). CHARLS is a nationally representative longitudinal survey of adults aged 45 years and older and their spouses. Through a multistage, stratified, probability proportional to size (PPS) sampling method, respondents from 28 provinces, 150 counties, and 450 communities in China were randomly selected. More details on this survey are provided elsewhere (Y. Zhao et al., 2014).

For the purposes of this analysis, the study utilizes data from the 2015 (Wave 3) and 2018 (Wave 4) waves of CHARLS. We will refer to the 2015 survey as our survey 'baseline' and the 2018 survey as its 'three-year follow-up'. We excluded samples that were aged <45 or had missing data on age at baseline, had incomplete data on hearing impairment or cognition estimates, and those without data on spouses or couples who were married but separated. Samples with marital dissolution, those lost to follow-up, and those with incomplete data on cognition estimates were further excluded in 2015. Ultimately, 4516 couples (9032 individuals) were included at baseline, and 2190 couples (4380 individuals) were included after the 3-year follow-up. Figure 1 presents the flowchart for sample selection. All participants in the CHARLS provided written informed consent, and this study was approved by the ethics committee of Peking University (approval code: IRB00001052-11015).

3.2 Measurements

3.2.1 Hearing Impairment

Our main independent variable was hearing impairment. Hearing impairment was self-assessed for both respondents and their spouses. All participants were asked "Do you have hearing problems?"

Respondents and spouses who answered “yes” were considered to have a hearing impairment (X. Zhao et al., 2021). Participants with hearing impairment in both the 2015 survey and the 2018 survey were defined as having pre-existing impairment, while those without impairment in the 2015 survey who developed impairment by the 2018 survey were defined as having recent-onset impairment. Couples in the 2018 survey were further categorized into dyads with pre-existing hearing impairment, dyads with recent-onset hearing impairment, and dyads without hearing impairment. Self-report measurement has been shown to be a reliable indicator of hearing impairment and could reflect a real functional disability compared to audiometry (Ask et al., 2010).

3.2.2 Cognitive Function

The outcome of interest in this study was cognitive function. In CHARLS, cognitive function was measured by mental intactness and episodic memory (Lei et al., 2012). Mental intactness was assessed through the Telephone Interview of Cognitive Status (TICS-10) test and a pentagon drawing test, which measured orientation, numeric ability, and visuospatial ability (Pan et al., 2022). TICS-10 is a widely recognized and globally accepted mental status test that does not rely on visual ability or literacy (Fong et al., 2009). Ten mental status questions from the TICS including serial subtraction of 7 from 100 (up to five times), and naming today’s date (month, week, day, year, and season). The summed range of TICS item scores varied from 0 to 10, with a Cronbach’s alpha of 0.782. Visuospatial ability was measured through the ability to reproduce a picture of two overlapping pentagons. The summed range of mental intactness scores vary from 0 to 11. Episodic memory includes immediate recall and delayed recall. Participants were asked to repeat 10 Chinese nouns immediately after given by interviewers (immediate recall) and to repeat the same list of words after a short delay (delayed recall). Episodic memory scores, ranging from 0 to 10, were calculated by averaging the scores of word list recall tests. Global cognition was calculated as the sum of mental intactness and episodic memory scores, with scores ranging from 0 to 21. Participants with higher scores were considered to have better cognitive function. The each-5-year-age stratified *z* scores of global cognition, mental intactness and episodic memory were then calculated to facilitate comparisons. Specifically, the *z* scores of global cognition and each cognitive function domain were standardized based on the baseline scores by subtracting the mean and dividing by the standard deviation (Ma et al., 2020).

3.2.4 Allostatic Load

In the CHARLS survey in 2015, physical examinations were conducted by trained interviewers, and venous blood was collected by staff at the China Center for Disease Control. We used 11 biomarkers from four physiological systems to construct the AL scores, following previous studies (Ye & He, 2022; Zhu et al., 2021). Systolic blood pressure and diastolic blood pressure were measured to indicate cardiovascular health. Biomarkers of the metabolic system included body mass index, high-density lipoprotein, low-density lipoprotein, total cholesterol, triglycerides, glycated hemoglobin, and glucose. The inflammation system was measured by C-reactive protein, and the renal system was measured by cystatin C and blood urea nitrogen. Details on the collection, transportation, storage, and laboratory assay of the blood samples and venous blood-based biomarkers have been described elsewhere (Chen et al., 2019).

Biomarkers were classified as dichotomous indicators (0 = low/medium-risk level, 1 =

high-risk) based on commonly used clinical cutoff points recommended by the manufacturer of the assay kit (Chen et al., 2019). The definition of cutoff points for high-risk levels for 11 biomarkers is presented in Table S1. AL scores were calculated as a count of these dichotomous indicators (range of 0–11), which is a prevailing method in the previous literature (Seeman et al., 2010; Xu, 2018). Higher AL scores indicate more severe degree of physiological damage caused by the cumulative impact of stress and life events on the body.

3.2.3 Symptoms of Depression

The Center for Epidemiological Studies Depression Scale short form (CES-D 10) was used to measure symptoms of depression in CHARLS (Y. Zhao et al., 2014). CES-D 10 is a 10-item measurement scale that contains the following items: (1) being bothered by things that are not usually bothersome; (2) having trouble keeping your mind on what you are doing; (3) feeling depressed; (4) feeling that everything you do is an effort; (5) feeling hopeful about the future; (6) feeling fearful; (7) restless sleep; (8) feeling happy; (9) feeling lonely; and (10) cannot get “going”. For each item, the participants reported the frequency of occurrence during the past week. To create the CES-D 10 summary, each item was scored on a 4-point scale, as follows: rarely or none of the time (≤1 day per week) = 0, some or a little of the time (1–2 days per week) = 1, occasionally or a moderate amount of the time (3–4 days per week) = 2, and most or all of the time (5–7 days per week) = 3. Before analysis, items 5 and 8 were reverse-scored to match the polarity of the other items. The summed range of CES-D 10 item scores varied from 0 to 30 (Cronbach’s alpha = 0.781), with higher scores indicating more severe symptoms of depression.

3.2.5 Social Participation

In CHARLS, social participation was measured asking respondents whether they had conducted the following leisure activities in the last month: (1) interacted with friends; (2) played Mahjong, chess, cards, or went to a community club; (3) provided help to family, friends, or neighbors who do not live with you; (4) went to a sports, social, or other kind of club; (5) took part in a community-related organization; (6) done volunteer or charity work; (7) cared for a sick or disabled adult who does not live with you; (8) attended an educational or training course; (9) stock investments; (10) used the Internet; and (11) other. Each item was dichotomized, with 0 indicating no participation and 1 indicating involvement. The total scores, ranging from 0 to 11, were calculated by summing scores from these questions, with higher scores indicating a greater diversity of social participation (Wang et al., 2019).

3.2.6 Covariates

The following covariates were considered: age (continuous), residence (urban, rural), education (illiterate, less than junior high school, junior high school, high school/vocational school, college or above), occupation (agricultural work, non-agricultural work, unemployed/retired), household wealth (low tertile, medium tertile, high tertile), marital satisfaction (continuous, with scores ranging from 1 to 5, where a higher score indicates greater marital satisfaction, smoking (never, former, current), and alcohol drinking (never, former, current but not heavy drinker, heavy drinker). Heavy alcohol consumption was defined as >2 drinks/day for men and >1 drink/ day for women. A standard drink in China was defined as 13.6 g of ethanol, which was equivalent to 375 ml of beer or 118 ml of wine (Ding et al., 2020; Zhang et al., 2021).

3.3 Statistical Analysis

In descriptive statistics, the continuous variables (age, marital satisfaction, AL, symptoms of depression, social participation, and cognitive function) are presented as medians with interquartile ranges (IQRs), and were examined by the Wilcoxon rank-sum test. Categorical variables (hearing impairment, residence, education, occupation, household wealth, smoking status, and alcohol consumption) are presented as frequencies and percentages and were examined using the chi-square test.

In the main analyses, an actor–partner interdependence model (APIM) was used to estimate the association between hearing impairment and cognitive function within married couples. APIM is a statistical method that commonly used to analyze interdependent data from dyad members (e.g., couples, parent and child, teacher and student, or doctor and patient) (David A. Kenny & Cook, 1999). The method allows us to estimate the unique contributions of husbands and wives' own hearing impairment to their own (actor effect) and their partner's (partner effect) cognitive function. We performed a distinguishability test in APIM to examine the existence of gender difference. A P-value < 0.2 for the chi-square test indicates differences in actor and partner effects between husbands and wives (D. A. Kenny & Ledermann, 2010). Then, the actor-partner interdependence mediation model (APIMeM) was used to conduct separate mediation analyses, computing the indirect effects of baseline AL, symptoms of depression, and social participation, respectively (Thomas Ledermann et al., 2011). When employing the APIM and APIMeM to examine the association between hearing impairment and cognitive function at the 3-year follow-up, baseline cognitive function z scores were included as an additional control variable.

Missing data were handled using multiple imputation before analyses. The combined results of the imputed datasets (n=50) are presented as pooled β values with 95% confidence intervals (CIs). The APIM and APIMeM will not provide goodness-of-fit statistics and will generate the same variance-covariance matrix because the model that includes the measured predictor and outcome variables is saturated in the dyadic structural equation modeling (SEM) analysis (T. Ledermann & Kenny, 2017).

Stata version 15 for Windows (Stata Corp, College Station, TX, USA) and Mplus version 8.3 (Muthén & Muthén, Los Angeles, CA, USA) were used to perform statistical analyses, and a two-sided $P<0.05$ was considered statistically significant.

3.4 Sensitivity Analysis

We repeated the APIM using another question from CHARLS related to hearing as the key independent variable for an association between hearing impairment and cognitive function. Respondents were asked, "Would you say your hearing is excellent, very good, good, fair, or poor (while wearing a hearing aid as usual, if relevant)?", and were required to rate their hearing function on a 5-point scale, with a higher score indicating greater severity of hearing impairment. The results of the association between baseline self-rated hearing function and baseline cognitive function are presented in Table S9. These analyses serve as a robustness check for our main analysis and revealed broadly similar results to our main analysis: poorer hearing function in individuals was associated with worse cognitive function in their spouses, and the partner effect of wives' hearing function was more pronounced than that of their counterparts.

4. Results

4.1 Characteristics of Participants

In total, 4516 married, opposite-sex couples were included in the study. The general characteristics of the participants at baseline are presented in Table 1. Overall, 14.1% of husbands and 11.8% of wives reported hearing impairment. Hearing aids were reported by 1.1% of husbands and 0.7% of wives. The median (IQR) age was 59.0 (14.0) years for husbands and 57.0 (13.0) years for wives. The participants were more likely to be rural residents (54.4%). Husbands were more likely to have a higher level of education, and a higher level of marital satisfaction, were more likely to be current smokers and current drinkers, and were less likely to be unemployed or retired than their wives (P <0.001).

The bivariate correlations for scores for cognitive function, AL, symptoms of depression, and social participation at baseline within and between partners are presented in Table S2. Individuals' cognitive function were significantly negatively correlated with their own and their spouses' hearing impairment. The distribution of independent variables, dependent variables, and mediators of participants stratified by spouses' hearing impairments are listed in Table S3 and S4. At the baseline, both husbands and wives who had spouses with hearing impairment were more likely to have worse cognitive function compared to those whose spouses did not have hearing impairment (P< 0.001). After the 3-year follow-up, significant differences were observed in both husbands' and wives' cognitive function among dyads with pre-existing hearing impairment, dyads with recent-onset hearing impairment, and dyads without hearing impairment.

4.2 Association between Hearing Impairment and Cognitive Function

The APIM analyses results of the associations between hearing impairment and baseline cognitive function within spouses are presented in Table S5. The results of the chi-square test indicate that actor and partner effects are distinguishable by gender roles in spouses ($P< 0.001$). After adjusting for all the covariates, husbands' hearing impairment exhibited no significant partner effect. In contrast, significant partner effect was found for the association between wives' hearing impairment and husbands' worse cognitive function.

The APIM estimates of actor and partner effects for the association between hearing impairment and cognition function three years later are presented in Table S6. The estimates for the longitudinal effects of pre-existing hearing impairment on cognitive function three years later are displayed in Figure 2. After adjusting for all the covariates, wives' pre-existing hearing impairment was negatively associated with their husbands' global cognition *z* scores three years later (β = -0.184, 95%CI: -0.299, -0.069). The same negative associations were found between wives' pre-existing hearing impairment and husbands' mental intactness *z* scores three years later. Additionally, the APIM results stratified by age are presented in Table S7. The partner effects for the association between wives' pre-existing and husbands' worse global cognition *z* scores three years later remained statistically significant among younger spouses (β = -0.221, 95%CI: -0.404, -0.039), and showed marginal significance among older spouses (β = -0.147, 95% CI: -0.308, 0.013, P=0.072).

4.3 Mediation Analyses

APIMeM analyses were conducted to examine possible mediation by AL, symptoms of depression, and social participation of the associations between hearing impairment and cognitive function among married couples. The results of the APIMeM analyses for the association between hearing impairment and baseline global cognition are presented in Table 2. There was a significant indirect effect of married women's hearing impairment on their husbands' baseline global cognition *z* score through more symptoms of depression in either wives or husbands (β = -0.039, 95% CI: -0.053, -0.024). This accounted for 33.3% of the total effect of wives' hearing impairment on husbands' cognitive function. The size of the indirect effect specifically mediated by wives' symptoms of depression was -0.014 (95% CI: -0.024, -0.004), whilst the indirect effect through husbands' symptoms of depression was estimated to be -0.024 (95% CI: -0.036, -0.012). There was also a significant indirect effect of wives' hearing impairment on husbands' cognitive function mediated by decreases in either partner's social participation (β = -0.019, 95% CI:-0.031, -0.007), which accounted for 15.4% of the total effect. However, we only found significant indirect effects through decreased social participation of husbands (β = -0.016, 95% CI: -0.027, -0.004). We found no evidence for an indirect effect through changes in the social participation of women (β = -0.003, 95% CI: -0.008, 0.002). The results are visually presented in Figures S1 and S2. The path through baseline symptoms of depression and reduced social participation from pre-existing hearing impairment to global cognition three years later was not statistically significant (Table S8). The associations between pre-existing hearing impairment amongst wives and symptoms of depression amongst themselves or their husbands remained significant (Figure S3).

5. Discussion

Hearing impairment has profound repercussions for impaired individuals throughout their entire life course. It is also of critical importance to married couples, who rely on hearing to connect through communication and experience challenges to maintaining closeness and intimacy to their partner in its absence (Bertschi et al., 2021). From a stress proliferation perspective, hearing impairment can be conceptualized as a stressor for individual members of a couple with spillover effects on the, well-being of spouses. Using nationally representative data of middle-aged and older married men and women in China, the current study examined the associations between one spouse's hearing impairment and the other's cognitive function by gender. Additionally, the current study also examined potential mechanisms underlying these associations.

The results indicate that hearing impairment among married women had a long-term negative impact on their husbands' cognitive health. Our results are consistent with previous research showing that hearing impairment is positively associated with cognitive impairment (Loughrey et al., 2018). Furthermore, findings from this study extend previous research, indicating that hearing impairment among married women can spill over to their husbands, resulting in worse cognitive function. We speculate that several possible reasons may explain why hearing impairment among married women has an adverse impact on husbands' cognitive health. Compared to women, men are socialized to exhibit less sensitivity in marital communication and pay less attention to maintaining quality of interactions with their wife (Acitelli, 1992). Therefore, when coping with miscommunication due to hearing impairment in their spouses, husbands may adopt negative coping strategies (e.g., avoiding emotionally deep conversations or reducing frequency of communication) rather than strategies that promote communication (e.g., repeating sentences with care or helping their spouses access treatment for hearing impairment) (Gomez & Madey, 2001). Quality and frequency of social interactions have been shown to reduce rates of cognitive decline (Samtani et al., 2022). Additionally, individuals with limited hearing function may face mobility restrictions, difficulties in the execution of daily chores, and impaired capacity for self-care due to impaired communication, balance, and spatial orientation, which requires care and assistance (Gopinath et al., 2012). In a marital context, traditional gender norms create expectations in men that they receive more care and support from their wives than vice versa and do not prepare men for being primary caregivers (Umberson et al., 2018). Having a wife with hearing impairment may create perceived unmet care needs amongst husbands and require them to adjust to a new unfamiliar, gender-atypical role as care provider in their spousal relationship. This may bring high levels of distress to husbands and may further undermine their cognitive health (X. Zhao et al., 2023a; X. Zhao et al., 2023b).

Our findings suggest that symptoms of depression and social participation may serve as potential mechanistic factors bridging the relationship between married women's hearing impairment and husbands' cognitive function. Previous research suggested that married women's hearing impairment is positively associated with symptoms of depression in both spouses (West, 2021; West et al., 2023). On the one hand, communication difficulties and subsequent withdrawal from conversation related to women's hearing impairment have been shown to be positively associated with relationship dissatisfaction and distress, potentially increasing risk of depression in either spouse (Kiecolt-Glaser & Wilson, 2017; Lehane et al., 2017). On the other hand, married women's hearing impairment is a physical health stressor directly associated with risks of depression in themselves and their husbands through emotional contagion (Monin et al., 2017; West, 2017). Evidence indicates that symptoms of depression are an early behavioral indicator for AD, which is associated with reduced hippocampal volume and subsequent cognitive decline (Gerritsen et al., 2022; Langella et al., 2023). We also found a potential mediating role of decreased social participation amongst husbands in the relationship between married women's hearing impairment and husbands' cognitive function. Our results are consisted with previous studies, indicating that hearing impairment is linked to reductions in social participation among married couples. Social interaction associated with greater cognitive capacity, and decreased social participation may accelerate cognitive decline among older adults (Sachdev, 2022). Although the mediating roles of symptoms of depression and social participation may not persist over longer periods of time, our results do indicate a long-term negative spillover effect of married women's hearing impairment on the mental wellbeing of their spouses. Follow-up studies are needed to verify the mechanism underlying the stress proliferation of hearing impairment within marriage.

We did not find evidence for an impact of hearing impairment amongst husbands on the cognitive health of their spouses. These findings suggest that negative impacts on cognitive health of having a partner with hearing impairment tend to be more pronounced for men than for women in our context. We speculated that the following possible reasons may explain gender differences. First, women are often socialized into devoting effort to their spouse's health (Umberson et al., 2018). Therefore, women may be more likely to detect early signs of their spouses' hearing function decline, tend to proactively adjust their own communication style to adapt to anticipated communication difficulties, and encourage their husbands to seek professional help. These positive coping strategies could mitigate the negative effects of hearing impairment for the married couple. Second, compared to their spouses, married women often have larger social networks and more close friends to fulfill needs related to companionship and support (Sauter et al., 2022). Under such circumstances, married women have access to a greater external pool of support to cope with the spillover effects of hearing impairment amongst their husbands. Our findings thus emphasize the importance of supporting married women's health and wellbeing for the betterment of the health and wellbeing of the couple as a whole.

Taking a family systems perspective, our results suggest that special attention should be paid to the health of older couples with hearing impairment. Our findings highlight the importance of improving ear and hearing care services in an ageing society, and add to evidence for the need to integrate hearing care into policies addressing cognitive decline. Given the adverse spillover effects of hearing impairment, we argue it is crucial to develop couple-oriented integrated interventions. Evidence from a meta-analysis of couple-oriented interventions for chronic conditions suggests that couple interventions could be more effective than traditional patient-oriented interventions, benefiting both partners of the dyad by improving quality of the marital relationship and encouraging the adoption of positive coping strategies (Martire et al., 2010). Such interventions could generate positive externalities for both members of the couple, thus reducing risk of cognitive disorders in both spouses.

Hearing aids are an effective technology for hearing rehabilitation, and their use may potentially help promote cognitive health and intervention with hearing impairment among married couples. Evidence from a randomized controlled trial has shown that hearing aid use significantly improves cognitive function and mental health in individuals with hearing impairment (Brewster et al., 2020; Davis et al., 2016). Furthermore, they can also reduce communication stress, which may mitigate the negative impacts of hearing impairment on the loss of shared activities and interactions with partners (Mamo et al., 2018). In China, rates of uptake of hearing aids are much lower than in developed countries, and awareness and knowledge of hearing health is generally low (He et al., 2018; Zheng et al., 2022). Therefore, it is necessary to promote knowledge of and positive attitude towards hearing impairment and provide affordable hearing aids to older adults in China.

Our study had several limitations. First, while marital quality is related to health (Robles et al., 2014), we were unable to estimate the effects of marital quality due to a lack of measures in CHARLS. For instance, we could not assess the potential mediating effects of anxiety and anger in the romantic relationship. However, we deemed that the effect of these marital quality related factors may not have been substantial, as our study excluded couples who were married but separated. Additionally, we partially controlled for the effects of marital quality by adjusting for self-reported marital satisfaction in our analysis, a key measure of marital quality (Bulanda et al., 2016). Second, we did not consider the potential role that hearing aid usage might play in the relationship between individuals' own hearing impairment and spouses' cognitive function as hearing aid usage was below 1.0%. Further studies are needed to evaluate whether wearing hearing aids mitigate the adverse effects of hearing impairment on the cognitive function of one's partner. Third, we cannot estimate potential confounding factors that may be related to cognitive function (e.g., physical activity, diet) due to data availability. These additional factors which may influence the association between hearing impairment and cognitive function should be considered in future studies. Fourth, couples excluded due to incomplete data on exposure or outcome were more likely to be older, and have more disadvantaged backgrounds (i.e., lived in rural area, lower level of educational attainment, engaged in agriculture work or unemployed) (Table S10)—this may have led to a slight underestimation of the associations between hearing impairment and cognitive function.

6. Conclusion

The results from this study demonstrate a negative impact of married women's hearing impairment on their husbands' cognitive health, suggesting that the negative impact of hearing impairment can spill over from one spouse to the other. Our findings provide important evidence that increasing access to hearing services and developing couple-based hearing interventions may be effective strategies for preventing cognitive impairment. They provide impetus for the need to build comprehensive and integrated health care systems that can care for hearing and cognitive health at the same time.

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Figures (NO AUTHOR DETAILS)

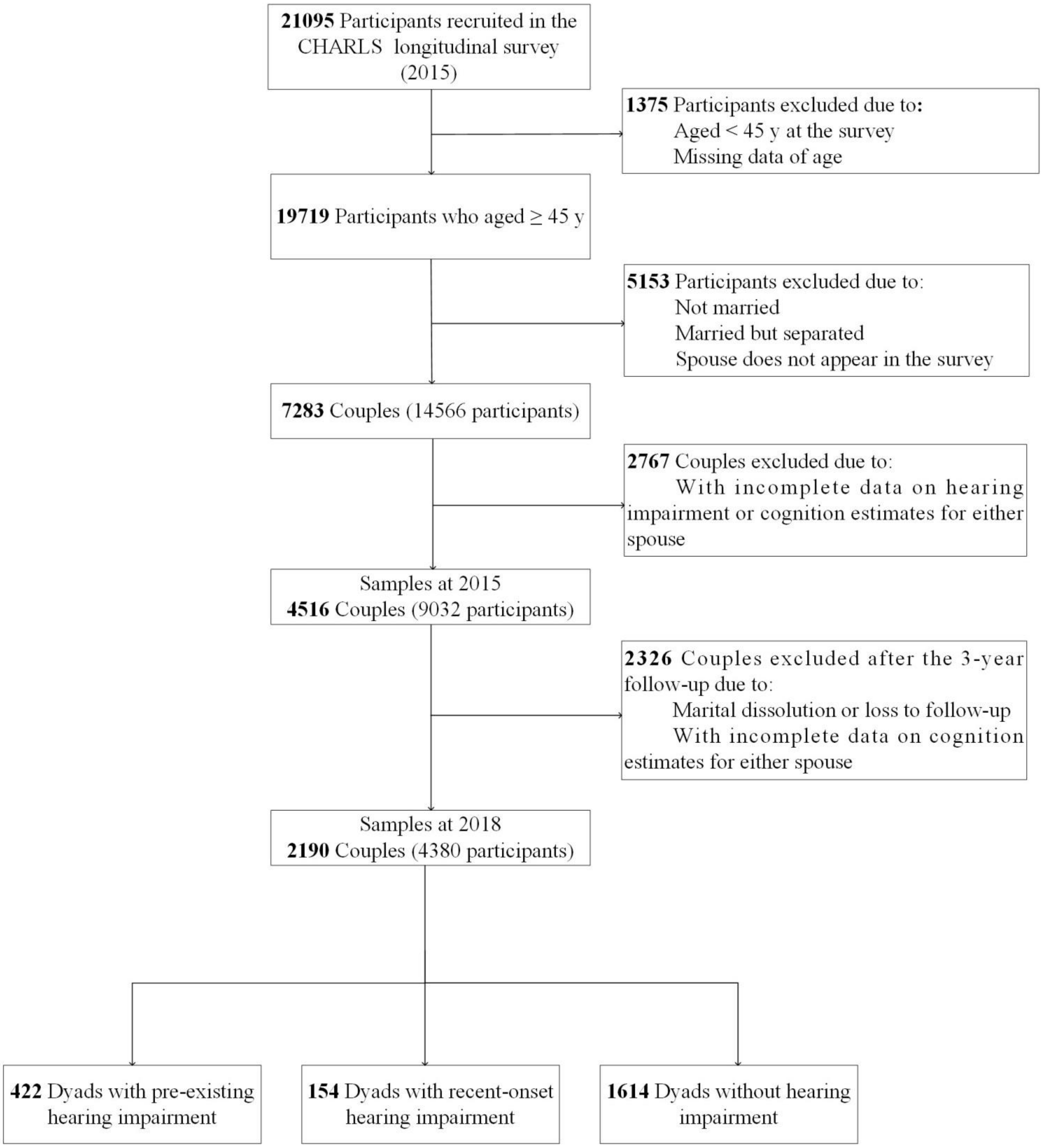

Figure 1. Flow chart of sample selection

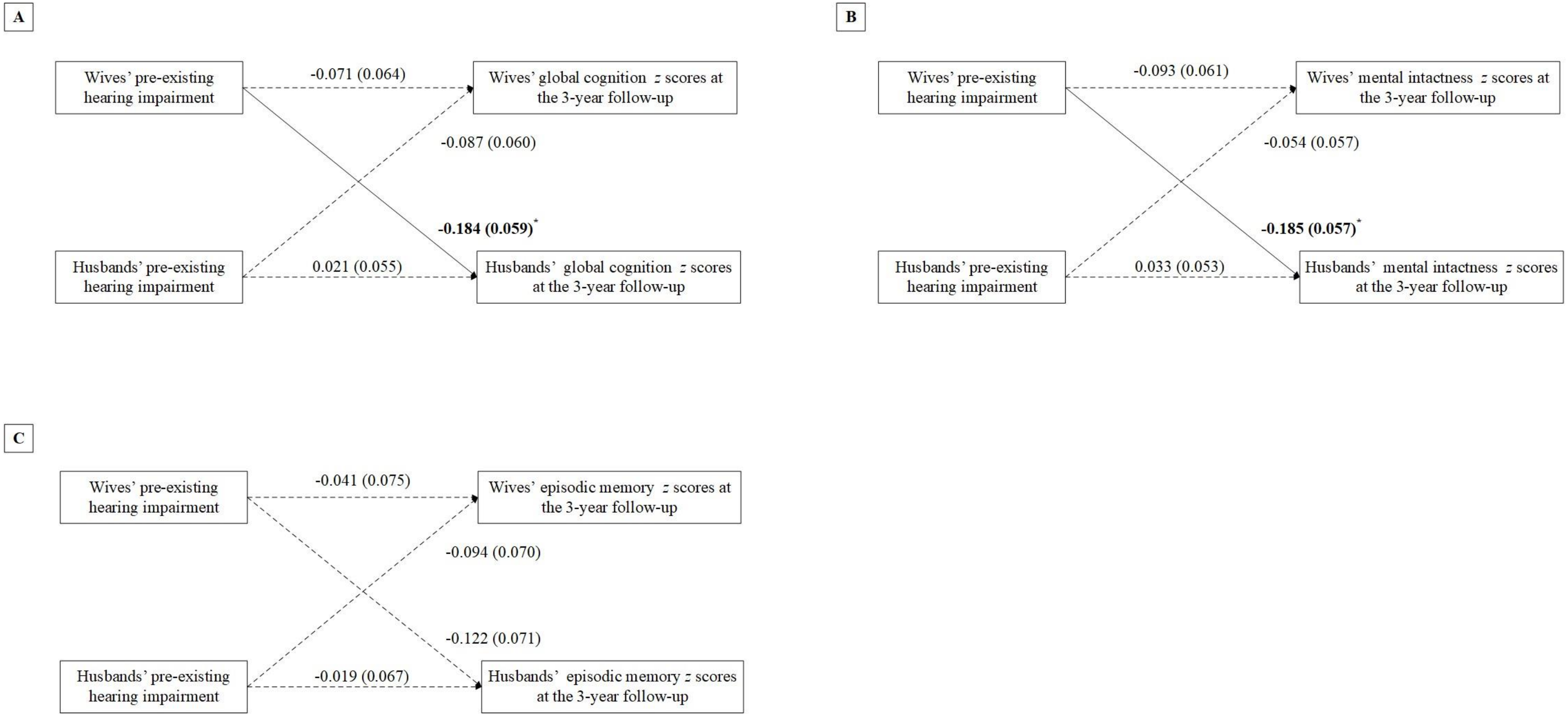

Figure 2. Actor–partner interdependence model estimates for pre-existing hearing impairment and cognitive function at the 3-year follow-up in married couples

Note. $^{*}P < 0.05$;

The models were adjusted for age, residence, education, occupation, household wealth, smoking, alcohol drinking, and baseline cognitive function z scores;

Solid lines indicate statistically significant pathways; dotted lines indicate statistically non-significant pathways;

Standard errors are presented in parentheses.

Table 1. Basic characteristics of participants, CHARLS, 2015 (N = 9032)

Characteristics, n (%)	Husbands (n=4516)	Wives (n=4516)	*P*
Hearing impairment			
Yes	638 (14.1)	535 (11.8)	0.001 [a]
No	3878 (85.9)	3981 (88.2)	
Wear hearing aid			
Yes	49 (1.1)	34 (0.7)	0.094 [a]
No	4467 (98.9)	4480 (99.3)	
Age (years), Median (IQR)	59.0 (14.0)	57.0 (13.0)	<0.001 [b]
45–59	2410 (53.4)	2711 (60.0)	<0.001 [a]
≥60	2106 (46.6)	1805 (40.0)	
Residence			
Urban	2061 (45.6)	2061 (45.6)	1.000 [a]
Rural	2455 (54.4)	2455 (54.4)	
Education			
Illiterate	253 (5.6)	1031 (22.8)	<0.001 [a]
Less than junior high school	2086 (46.2)	2058 (45.6)	
Junior high school	1288 (28.5)	940 (20.8)	
High school/vocational school	731 (16.2)	425 (9.4)	
College or above	158 (3.5)	62 (1.4)	
Occupation			

Agricultural work	1395 (30.9)	1677 (37.1)	
Non-agricultural work	1927 (42.7)	1129 (25.0)	<0.001 [a]
Unemployed/retired	1127 (24.9)	1620 (35.9)	
Missing	67 (1.5)	90 (2.0)	
Household wealth			
Low tertile	1322 (29.3)	1322 (29.3)	
Medium tertile	1216 (26.9)	1216 (26.9)	1.000 [a]
High tertile	1269 (28.1)	1269 (28.1)	
Missing	709 (15.7)	709 (15.7)	
Marital satisfaction, Median (IQR)	4.0 (1.0)	3.0 (1.0)	<0.001 [b]
Smoking			
Never	864 (19.1)	4181 (92.6)	
Former	1334 (29.6)	134 (3.0)	<0.001 [a]
Current	2318 (51.3)	200 (4.4)	
Alcohol drinking			
Never	1148 (25.4)	3549 (78.6)	
Former	624 (13.8)	292 (6.5)	
Current but not heavy drinker	2632 (58.3)	642 (14.2)	<0.001 [a]
Heavy drinker	109 (2.4)	33 (0.7)	
Missing	3 (0.1)	0 (0.0)	

Note. [a] Chi-square test; [b] Wilcoxon rank-sum test.

Abbreviations: IQR, interquartile range.

Table 2. Actor-partner interdependence mediation models estimates for testing the indirect effect of mediators on the association between hearing impairment and baseline global cognition *z* scores, β [a] (95% CI)

Predictors	Effects	Mediators		
		AL	Symptoms of depression	Social participation
Husbands' hearing impairment	Actor effect			
	Total	-0.195 (-0.265, -0.126)	-0.208 (-0.277, -0.139)	-0.217 (-0.286, -0.148)
	Total indirect	-0.001 (-0.005, 0.003)	-0.048 (-0.061, -0.034)	-0.035 (-0.047, -0.023)
	Actor-actor	0.000 (-0.003, 0.003)	-0.039 (-0.052, -0.026)	-0.032 (-0.044, -0.020)
	Partner-partner	0.000 (-0.004, 0.003)	-0.009 (-0.016, -0.002)	-0.003 (-0.007, 0.002)
	Direct	-0.195 (-0.264,-0.125)	-0.160 (-0.229, -0.092)	-0.182 (-0.251, -0.114)
	Partner effect			
	Total	-0.018 (-0.099, 0.062)	-0.029 (-0.109, 0.052)	-0.030 (-0.111, 0.050)
	Total indirect	-0.004 (-0.009,0.001)	-0.048 (-0.065, -0.030)	-0.024 (-0.037, -0.012)

	Actor-partner	-0.001 (-0.005,0.002)	-0.007 (-0.017, 0.002)	-0.005 (-0.013, 0.003)
	Partner-actor	-0.003 (-0.007,0.001)	-0.040 (-0.056, -0.025)	-0.019 (-0.030, -0.008)
	Direct	-0.014 (-0.094, 0.066)	0.019 (-0.060, 0.098)	-0.006 (-0.086, 0.074)
Wives' hearing impairment	Actor effect			
	Total	-0.180 (-0.266, -0.095)	-0.194 (-0.279, 0.108)	-0.193 (-0.279, 0.107)
	Total indirect	-0.004 (-0.013, 0.004)	-0.068 (-0.087, -0.049)	-0.022 (-0.034, -0.011)
	Actor-actor	-0.006 (-0.013, 0.001)	-0.064 (-0.082, -0.045)	-0.020 (-0.031, -0.008)
	Partner-partner	0.001 (-0.002, 0.005)	-0.005 (-0.011, 0.002)	-0.003 (-0.007, 0.002)
	Direct	-0.176 (-0.262, -0.090)	-0.125 (-0.210, -0.041)	-0.171 (-0.256, -0.086)
	Partner effect			
	Total	-0.105 (-0.179, -0.032)	-0.117 (-0.190, -0.044)	-0.123 (-0.196, -0.050)
	Total indirect	-0.001 (-0.007, 0.006)	-0.039 (-0.053, -0.024)	-0.019 (-0.031, -0.007)
	Actor-partner	-0.001 (-0.007, 0.005)	-0.014 (-0.024, -0.004)	-0.003 (-0.008, 0.002)

Partner-actor	0.000 (-0.003, 0.004)	-0.024 (-0.036, -0.012)	-0.016 (-0.027, -0.004)
Direct	-0.105 (-0.178, -0.031)	-0. 078 (-0.151, -0.006)	-0.104 (-0.177, -0.032)

Note. [a] Adjusted for age, residence, education, occupation, household wealth, marital satisfaction, smoking, alcohol drinking.

Abbreviations: AL, allostatic load; CI, confidence intervals.