



OPEN ACCESS

EDITED BY

Kiyotaka Nemoto,
University of Tsukuba, Japan

REVIEWED BY

Ciro Gaona,
Alzheimer's Foundation of Venezuela,
Venezuela
Akiko Noda,
Chubu University, Japan

*CORRESPONDENCE

Chee H. Ng
✉ cng@unimelb.edu.au
Yu-Tao Xiang
✉ xyutly@gmail.com
Gang Wang
✉ gangwangdoc@ccmu.edu.cn

†These authors have contributed equally to this work

RECEIVED 19 February 2025

ACCEPTED 20 June 2025

PUBLISHED 15 July 2025

CITATION

Fan H-Y, Sun H-L, Feng Y, Zhang Q, Xing H-Q, Huang Q-H, Su Z, Cheung T, Ng CH, Xiang Y-T and Wang G (2025) Nonlinear associations of depression and sleep duration with cognitive impairment in older adults with hypertension: findings from a national survey. *Front. Aging Neurosci.* 17:1579560. doi: 10.3389/fnagi.2025.1579560

COPYRIGHT

© 2025 Fan, Sun, Feng, Zhang, Xing, Huang, Su, Cheung, Ng, Xiang and Wang. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](#). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Nonlinear associations of depression and sleep duration with cognitive impairment in older adults with hypertension: findings from a national survey

Hui-Ying Fan^{1,2,3†}, He-Li Sun^{2,3†}, Yuan Feng^{4†}, Qinge Zhang^{4†}, Hua-Qing Xing^{2,3}, Qian-Hua Huang^{2,3}, Zhaohui Su⁵, Teris Cheung⁶, Chee H. Ng^{7*}, Yu-Tao Xiang^{2,3*} and Gang Wang^{4*}

¹International Nursing School, Hainan Medical University, Haikou, Hainan, China, ²Unit of Psychiatry, Department of Public Health and Medicinal Administration, Faculty of Health Sciences, University of Macau, Macao SAR, China, ³Centre for Cognitive and Brain Sciences, University of Macau, Macao SAR, China, ⁴Beijing Key Laboratory of Mental Disorders, National Clinical Research Center for Mental Disorders and National Center for Mental Disorders, Beijing Anding Hospital, Capital Medical University, Beijing, China, ⁵School of Public Health, Southeast University, Nanjing, China, ⁶School of Nursing, Hong Kong Polytechnic University, Hong Kong SAR, China, ⁷Department of Psychiatry, The Melbourne Clinic and St Vincent's Hospital, University of Melbourne, Richmond, VIC, Australia

Objectives: Cognitive impairment is a major health concern in older adults with hypertension, and both depression and abnormal sleep duration are recognized as potential contributing factors. This study aimed to explore the nonlinear association of depression and sleep duration with cognitive impairment among older adults with hypertension.

Methods: This cross-sectional study was based on the 2017–2018 wave of Chinese Longitudinal Healthy Longevity Survey. Depression and cognitive function were measured using the 10-item Center for Epidemiological Studies Short Depression Scale and Mini Mental State Examination, respectively. Univariate, binary logistic regression, and restricted cubic spline regression analyses were used to examine the associations between depression, sleep duration and cognitive impairment.

Results: A total of 3,989 older adults with hypertension were included. The prevalence of depression and cognitive impairment were 28.1% (95%CI = 26.7–29.5%) and 10.1% (95%CI = 9.2–11.1%), respectively. After adjusting for confounding factors, a significant linear association (nonlinear $p = 0.814$) between depression and cognitive impairment risk was found, while a U-shaped nonlinear association was identified between sleep duration and cognitive impairment risk ($p = 0.040$). Both shorter (<6.6 h) and longer (>7.7 h) sleep duration per day were associated with higher cognitive impairment risk, with an inflection point at 7.3 h. The effect of sleep duration on cognitive impairment risk was more significant for participants with a higher (≥ 6 years) education level.

Conclusion: This study highlights the importance of managing depression and optimizing sleep duration in addressing the risk of cognitive decline in older adults with hypertension.

KEYWORDS

older adults, hypertension, cognitive impairment, depression, sleep duration

1 Introduction

Hypertension is a highly prevalent chronic condition in older adults worldwide. With the rapidly aging population in China, there has been a substantial increase in the hypertension cases over past decades, with nearly half of adults over 65 affected (Tan et al., 2023; Wang et al., 2024). Hypertension is associated with specific cognitive impairment, particularly with regards to the development of vascular dementia and Alzheimer's disease (Ungvari et al., 2021), thus increasing the burden on families and society (Lv et al., 2019). These links may be related to pathological changes in cerebral blood vessels induced by hypertension, contributing to cognitive decline. Such changes include remodeling (Scuteri et al., 2011a; Martinez-Lemus et al., 2009), dysregulation of blood flow and impaired cerebral perfusion (Pires et al., 2015; Capone et al., 2012). In a meta-analysis of 11 international studies, the estimated prevalence of mild cognitive impairment in hypertensive adults over age 60 was 28% [95% confidence interval (CI) = 23–33%] (Qin et al., 2021), highlighting the need to identify the associated risk factors in order to inform early intervention strategies and prevent cognitive impairment.

Depressive symptoms (hereafter depression) are common among older adults with hypertension, affecting up to 34% of this population (Yena et al., 2024). Multiple studies have consistently found a strong link between depression and cognitive impairment, with one analysis showing that depression nearly doubles the risk of poor cognitive performance among older adults [adjusted odds ratio (OR) = 2.25; 95%CI = 1.31–3.81] (Yao et al., 2024; Yin et al., 2024). Several studies have shown bidirectional relationships between depression and cognitive impairment (Guo et al., 2023; Huang et al., 2022; Yin et al., 2024). While many studies have explored the linear depression-cognitive impairment relationship, few have investigated their potential nonlinear association, especially in hypertensive older adults. One study revealed a J-shaped association between depression and cognitive decline in older adults in the US (Yao et al., 2024), while others only found linear relationships (Wu et al., 2024). Given such inconsistent findings, examining the potential nonlinear relationships could provide a deeper understanding of how depressive symptoms impact cognitive decline, potentially guiding targeted interventions for older adults with hypertension.

On the other hand, sleep duration is crucial for maintaining cognitive health. Adequate sleep supports cognitive processes, memory consolidation and the clearance of brain metabolic waste (Diekelmann, 2014; Wigren and Stenberg, 2015). Both shorter and longer sleep duration are known to be risk factors of hypertension (Pepin et al., 2014; Grandner et al., 2018) and are common among older adults with hypertension, often adversely impacting the overall quality of life (Kielbasa et al., 2016; Uchmanowicz et al., 2019). One study found that self-reported sleep disturbances were linked to reduced cognitive performance among older adults with hypertension (Kohn et al., 2020). While other studies have found associations between sleep duration problems and cognitive impairment across various domains (e.g., recall, verbal fluency, and visual memory) (Henry et al., 2019; Warsame et al., 2023; Giannouli, 2017), there are contentious findings on the direction of such associations (Li et al.,

2022; Ma et al., 2020; Albert, 2019; Suh et al., 2018). Certain studies identified U-shaped relationships, where both short and long sleep duration increase the risk of cognitive impairment (Ma et al., 2020; Li et al., 2022), whereas others found that only long sleep duration was associated with cognitive impairment, particularly among older adults (Zhang et al., 2022; Ding et al., 2024) and those with hypertension (Zhou et al., 2022). Thus, to clarify the trends or underlying mechanisms of the impact of sleep, the nonlinear association between sleep duration and cognitive impairment, particularly in older adults with hypertension, requires further investigation.

To address this gap, we examined the prevalence of cognitive impairment and depression among older adults with hypertension, and explore potential nonlinear associations between depression, sleep duration and cognitive impairment based on a national survey.

2 Methods

2.1 Study design and samples

This was a cross-sectional study based on the data from the 2017–2018 wave of the Chinese Longitudinal Healthy Longevity Survey (CLHLS) (Center for Healthy Aging Development Studies, 2020). The CLHLS is an ongoing, national cohort survey based on multi-stage random sampling across 23 of the 32 provinces in China (Zheng, 2020). The survey has been conducted every 2 to 3 years since 1998, with methodology details available in previous publications (Yu et al., 2021; Zeng et al., 2017). The inclusion criteria for participation in this study included: (1) participants aged 65 or older (Bai et al., 2023; Rodda et al., 2011), (2) presence of hypertension according to records from the CLHLS database, and (3) available data for depression, cognitive function, sleep duration and other included variables in this study. Following previous research (Bai et al., 2023), individuals with severe cognitive impairment, such as dementia, were excluded from the study. Ethical approval for the CLHLS was granted by the Peking University Research Ethics Committee (No. IRB00001052-13074), and all participants provided written informed consent.

2.2 Measurements

Cognitive function was evaluated using the validated Chinese version of the Mini-Mental State Examination (MMSE) (Folstein et al., 1975; Katzman et al., 1988). The MMSE includes 24 items assessing six dimensions: Orientation (5 items), Registration (3 items), Naming (1 item), Attention and Calculation (5 items), Recall (3 items), and Language (7 items). Each item was scored as zero (wrong or unable to answer) or one (correct), except for the Naming item that was scored from zero to seven according to the number of correct responses. The total scores range from 0 to 30, with lower scores representing poorer cognitive function. Because MMSE scores can be affected by education, following previous studies (Wu et al., 2019; Liang et al., 2022), cognitive impairment was defined in this study using education-specific cutoffs: <18, ≤20 and ≤24 for participants

with illiteracy, 1–6 years of primary education and more than 6 years of junior or higher education, respectively.

Depression was measured with the validated Chinese version of 10-item Center for Epidemiologic Studies Short Depression Scale (CESD-10) (Andresen et al., 1994; Chen and Mui, 2014). This scale assesses the frequency of occurrence of depressive symptoms in the previous week from 0 ('rarely or none of the time; <1 day') to 3 ('most or all of the time; 5–7 days'). Items 5, 7 and 10 are reversely scored. The total score ranges from 0 to 30 with higher scores indicating more severe depressive symptoms. A cut-off score of 10 was applied to identify individuals having depression (Andresen et al., 1994).

Sleep duration was evaluated with a specific question "How many hours do you usually sleep?." Socio-demographic covariates included variables such as gender, age, place of residence, education level, marital status, cohabitation with family, and perceived economic status. Physical function was measured using the 8-item Lawton Instrumental Activities of Daily Living (IADL) scale (Lawton and Brody, 1969; Tong and Man, 2002), with each item being rated from 1 (complete dependence) to 3 (complete independence). The total score ranges from 8 to 24, with higher scores indicating greater independence (Yang et al., 2023).

2.3 Statistical analysis

All statistical analyses were conducted using R (version 4.3.2) (R Development Core Team, 2020). Depression prevalence, sleep duration and other covariates were compared between groups with cognitive decline and no cognitive decline using chi-square and independent two-sample Wilcoxon rank sum test, as appropriate. Multivariable analysis was performed using binary logistic regression (enter method) to identify factors independently associated with cognitive impairment. Cognitive impairment served as the dependent variable, while variables showing significant group differences in univariable analyses were included as independent variables. Adjusted ORs with 95% CIs were computed to quantify the association strengths.

Restricted cubic spline (RCS) regression is widely used for characterizing dose–response relationships between continuous exposures and outcomes when nonlinearity is suspected (Croxford, 2016). The RCS curves, fitted with three knots, were used to investigate the potential nonlinear association between depression (as a continuous variable), sleep duration and cognitive impairment, after adjusting for covariates that showed significant differences in the multivariable analysis. Statistical significance was set at $p < 0.05$ (two-tailed) for all analyses.

3 Results

3.1 Participant characteristics

A total of 3,989 older adults with hypertension were included in this study. Their demographic and clinical characteristics are shown in Table 1. Among the participants, the majority were female (56.6%), had six or fewer years of education (74%), resided in urban areas (62.9%) and lived with their family (78.6%). The mean age was 81.80 [Standard Deviation (SD) = 10.42] years. The mean sleep duration was 7.23 (SD = 2.19) hours per day.

3.2 Prevalence of depression and cognitive impairment

The overall prevalence of depression (CESD-10 total score ≥ 10) among older adults with hypertension was 28.1% ($n = 1,120$, 95% CI = 26.7–29.5%), while the prevalence of cognitive impairment was 10.1% ($n = 402$; 95% CI = 9.2–11.1%).

3.3 Correlates of cognitive impairment

Univariable analyses (Table 1) showed that participants with cognitive impairment were more likely to suffer from depression (45.3% vs. 26.1%, $p < 0.001$) and have longer sleep duration [7.65 (SD = 2.78) hours vs. 7.18 (SD = 2.11) hours per day, $p = 0.004$] compared to the non-cognitive impairment group. After controlling for confounders with logistic regression analysis, participants with depression (OR = 1.539, $p < 0.001$) had a significantly higher risk of cognitive impairment, while no significant link between sleep duration and cognitive impairment was found. Additionally, participants with higher education level (OR = 1.698, $p = 0.001$) and older age (OR = 1.064, $p < 0.001$) had a significantly higher risk of cognitive impairment, while those with better physical function had a lower risk of cognitive impairment (OR = 0.841, $p < 0.001$) (Figure 1).

3.4 Nonlinear association between depression, sleep duration and cognitive impairment

After adjusting for confounding factors, RCS regression demonstrated that there was a linear association between depression and cognitive impairment risk (nonlinear $p = 0.814$, Figure 2), but a U-shaped nonlinear association existed between sleep duration and cognitive impairment risk ($p = 0.040$, Figure 3). Both shorter (<6.6 h) and longer (>7.7 h) sleep duration per day were associated with higher cognitive impairment risk, with an inflection point at 7.3 h per day. Figure 4 illustrates the nonlinear relationship by different education levels. The OR values of participants with over 6 years of education were generally higher than those of participants with lower education level, indicating that for participants with a higher education level, the effect of sleep duration on cognitive impairment risk might be more significant.

4 Discussion

This was the first study to examine the nonlinear associations between depression, sleep and cognitive impairment in a hypertensive older adult population.

4.1 Prevalence of cognitive impairment and depression

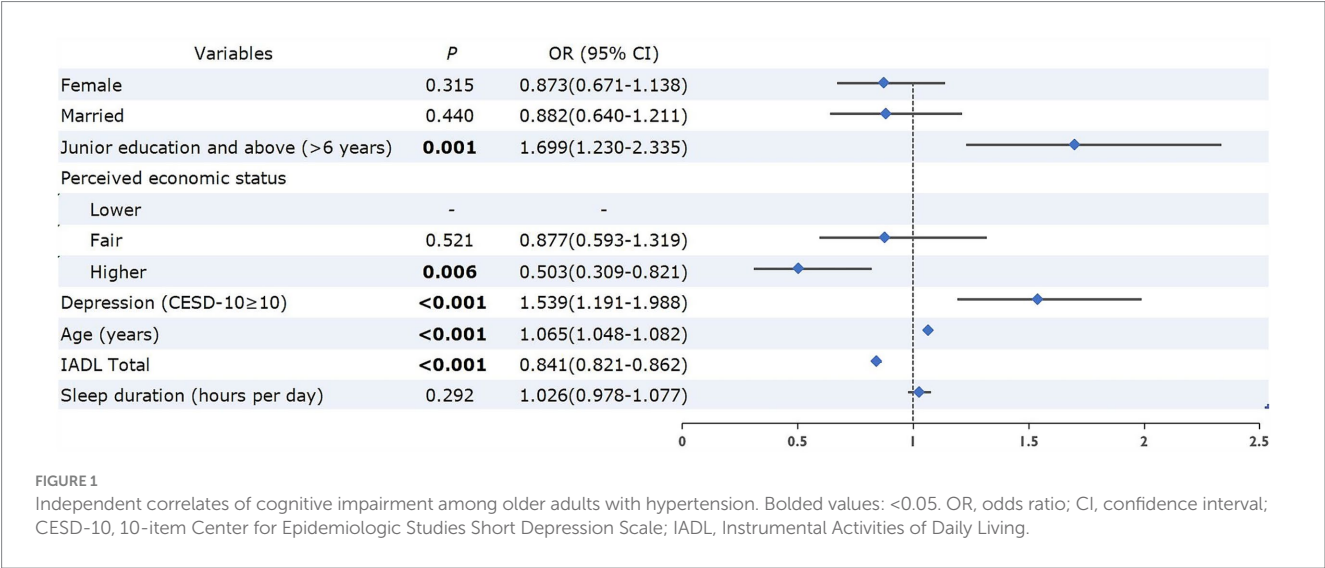
In this study, the prevalence of cognitive impairment was 10.1% (95% CI = 9.2–11.1%), which is lower than the results of a meta-analysis in China that found pooled prevalence rates of 17% (95% CI = 15–19%) in community-based hypertensive patients and 19%

TABLE 1 Comparisons of socio-demographic data between cognitive impairment and non-cognitive impairment groups among older adults with hypertension.

Variable	Total (N = 3,989)		Non-cognitive impairment (N = 3,587)		Cognition impairment (N = 402)		Univariable analyses		
	N	%	N	%	N	%	χ^2	df	p
Female	2,259	56.6	2,009	56.0	250	62.2	5.624	1	0.018
Rural residence	1,481	37.1	1,335	37.2	146	36.3	0.125	1	0.723
Married	1,909	47.9	1,824	50.9	85	21.1	127.830	1	<0.001
Living with family	3,134	78.6	2,822	78.7	312	77.6	0.242	1	0.623
Junior education or above (>6 years)	1,037	26.0	953	26.6	84	20.9	6.306	1	0.012
Perceived economic status									
Lower	333	8.3	288	8.0	45	11.2	14.190	2	<0.001
Fair	2,776	69.6	2,481	69.2	295	73.4			
Higher	880	22.1	818	22.8	62	15.4			
Depression (CESD-10 $\geq$ 10)	1,120	28.1	938	26.1	182	45.3	65.466	1	<0.001

	Mean	SD	Mean	SD	Mean	SD	Z	df	p
Age (years)	81.80	10.42	80.64	9.91	92.20	8.98	20.006	-	<0.001
IADL Total	19.66	5.42	20.45	4.84	12.62	5.24	-23.833	-	<0.001
Sleep duration (hours per day)	7.23	2.19	7.18	2.11	7.65	2.78	2.916	-	0.004

Bolded values: <0.05; df, degree of freedom; SD, standard deviation; CESD-10, 10-item Center for Epidemiologic Studies Short Depression Scale; IADL, Instrumental Activities of Daily Living.



(95% CI = 15–23%) in the subgroup using MMSE scale (Qin et al., 2021). In another study, the prevalence of cognitive impairment among hypertensive adults aged 55 and older in China was 19.1% (95% CI = 19–25.3%) (Deng et al., 2021). One possible reason for the lower prevalence observed in this study was that the cognitive impairment was defined using education-specific cutoffs. As our sample exhibited generally low education levels, therefore, most of the sample in this study defined cognitive impairment using cutoff scores

of <18 and $\leq$ 20, rather than scores of $\leq$ 24 used in other studies. Moreover, a previous study (Cui et al., 2011) found that in a low-education Chinese population the prevalence of cognitive impairment screening with the education-specific cutoff scores was lower than that with the scores of 23/24 cutoff (7.0% vs. 35.6%), thus supporting the reliability of the education-specific cutoff scores. The prevalence of depression in this study was 28.1% (95%CI = 26.7–29.5%), which is line with prevalence of 28%

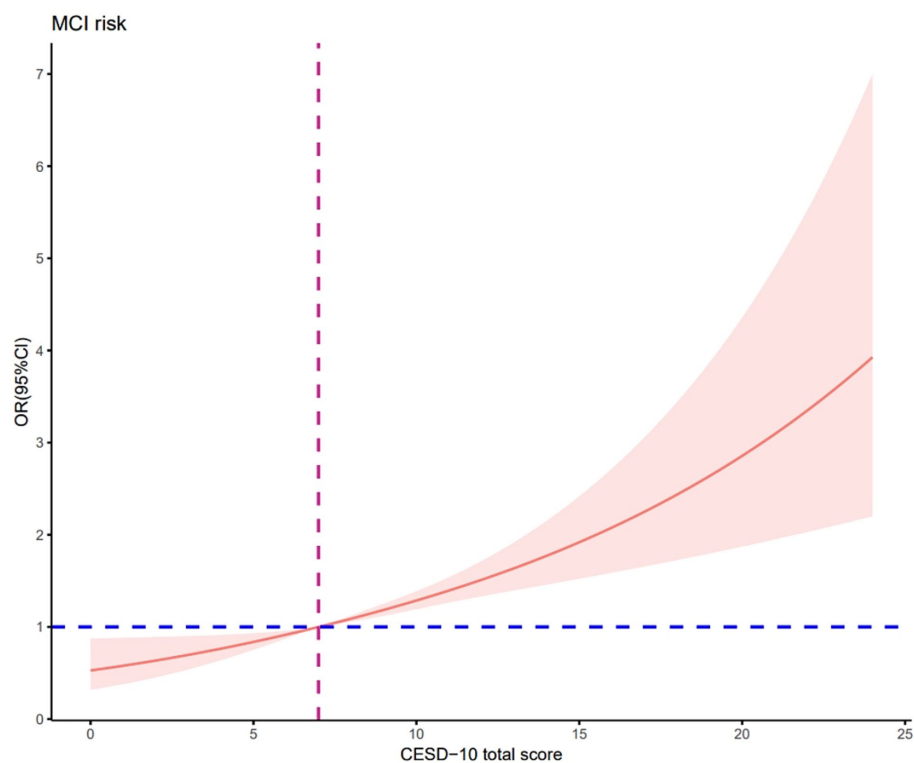


FIGURE 2

Restricted cubic spline regression of CESD-10 score and cognitive impairment risk. Data were fitted by a 3-knotted restricted cubic spline logistic regression model, adjusted for age, education level and IADL. Nonlinear test: $\chi^2 = 0.06$, $df = 1$, $p = 0.814$; OR = 1, CESD-10 total score = 7.0.

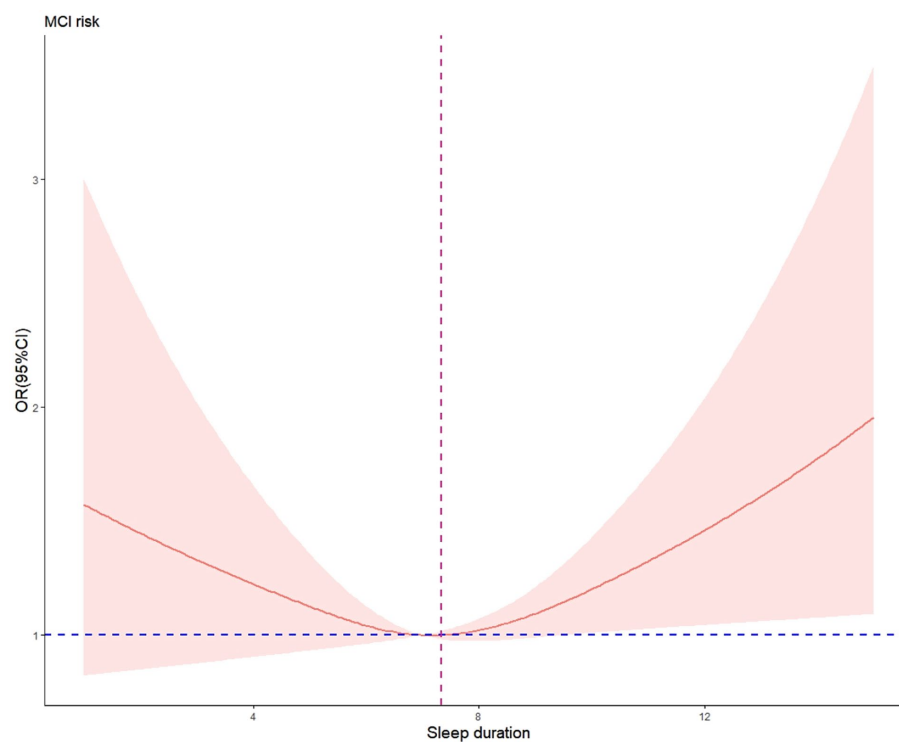


FIGURE 3

Nonlinear association of sleep duration and cognitive impairment risk. Data were fitted by a 3-knotted restricted cubic spline logistic regression model, adjusted for age, education level, IADL and depression. Nonlinear test: $\chi^2 = 4.19$, $df = 1$, $p = 0.041$; OR = 1, sleep duration = 7.3.

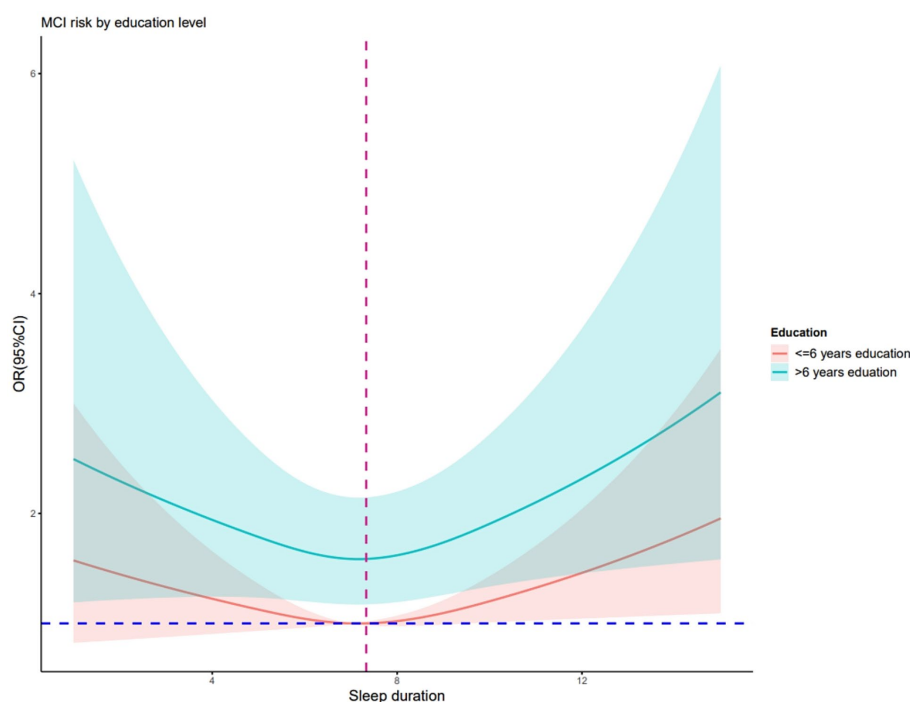


FIGURE 4

Nonlinear association of sleep duration and cognitive impairment risk regarding different education years Data were fitted by a 3-knotted restricted cubic spline logistic regression model, adjusted for age, education level, IADL and depression.

(95%CI = 20–36%) found in a meta-analysis of studies among older adults with hypertension across six countries (Gan et al., 2023). However, our finding was lower than that of the subgroup analysis for China (35%, 95%CI = 29–41%) but higher than the prevalence of the other included countries (16%, 95%CI = 8–26%). Differences across studies might be due to variations in study design such as sampling methods, sample sizes and assessment tools as well as the characteristics of the study samples.

4.2 Linear relationship between depression and cognitive impairment

This study found that hypertensive older adults with depressive symptoms had a higher risk of cognitive impairment (OR = 1.539, 95%CI = 1.191–1.988), which is consistent with findings from previous cross-sectional and cohort studies in older adults showing that severity of depression is positively associated with significant cognitive decline (Muhammad and Meher, 2021; Liu et al., 2023; Wei et al., 2019; Zhou et al., 2021). For instance, a cross-sectional study (Zhou et al., 2021) demonstrated that depression severity among older adults was negatively correlated with cognitive performance across all dimensions (i.e., orientation, memory, attention and calculation, as well as language) as measured by MMSE score. After controlling for age, gender and comorbidities, previous research also found that the combination of hypertension and depression substantially raises the risk of cognitive impairment (OR = 2.02, 95%CI = 1.60–2.54) (Scuteri et al., 2011b). Similarly, a retrospective cohort study revealed that older women with cumulative depressive symptoms had a two-fold

increased risk of cognitive impairment and dementia (Zeki Al Hazzouri et al., 2014).

Furthermore, we identified a linear relationship between the CESD-10 total score and cognitive impairment risk, which aligns with another study that used the CLHLS data to explore such nonlinear relationship in older adults (Wu et al., 2024). Our results of RCS regression corroborated with those from logistic regression, reinforcing the finding that higher depression levels are associated with increased risk of cognitive decline in this population. In contrast, two studies using larger samples from the CLHLS (N = 13,840) and National Health and Nutrition Examination Survey (NHANES) respectively, identified a J-shaped nonlinear association between depression and cognitive impairment among older adults (Ding et al., 2024; Yao et al., 2024). This discrepancy might be due to the differences between older adults with hypertension and general older adult population. Additionally, variations in sample size, measurement tools and covariates included in the RCS regression could contribute to the different results. Therefore, it is essential to validate these findings in future research using larger samples of older adults with hypertension.

One possible mechanism linking depression and cognitive impairment is neurotransmitter disruption (e.g., dopamine and serotonin), which is closely associated with the development of certain mental health problems, such as depression, and can negatively impact cognitive function such as memory and executive functioning (Sierksma et al., 2010). Moreover, depressive symptoms frequently coexist with anxiety and psychological stress, which can further affect cognitive functioning negatively (Kraynak and Andreescu, 2022). These findings highlight the critical need for integrated mental health care for older adults with hypertension to address cognitive

impairment. Interventions targeting depression not only can enhance mental health outcomes but also potentially alleviate cognitive decline.

4.3 U-shaped nonlinear association between sleep duration and cognitive impairment risk

Although binary logistic regression analysis revealed no linear association between sleep duration and cognitive impairment, RCS regression identified a significant U-shaped nonlinear association after adjusting for confounding factors, with both short and prolonged sleep duration linked to a higher risk of cognitive impairment. This finding is consistent with studies in older adults showing that both insufficient and excessive sleep could negatively impact cognitive function (Ma et al., 2020; Song et al., 2024), but is inconsistent with studies reporting a J-shaped relationship where only long sleep duration was associated with the risk of cognitive impairment among older adults (Zhang et al., 2022; Ding et al., 2024). In contrast, a meta-analysis found that both insufficient and excessive sleep duration increased the risk of cognitive decline among older adults (Lo et al., 2016), and another systematic review demonstrated a U-shaped dose-response relationship between sleep duration and cognitive impairment (Wu et al., 2018). Additionally, a previous longitudinal study found that both short and long sleep duration were linked to the onset of mild cognitive impairment (MCI) in middle-aged and older populations (Liu et al., 2022), which supports the findings of this study.

This study indicated that the ideal range for older adults with hypertension was 6.6 to 7.7 h of sleep per day, with 7.3 h per day being identified as having the lowest risk of cognitive impairment. Similarly, previous studies found that sleep duration less than 6 h or more than 8 h per day could negatively affect cognitive function (Song et al., 2024; Li et al., 2022). Specifically, older adults sleeping under 6 h per day faced a 30% higher dementia risk compared to those with typically 7-h sleep duration (Sabia et al., 2021).

We found that participants with higher education level (>6 years) had a high risk of cognitive impairment in logistic regression, which is inconsistent with previous findings that lower education was associated with MCI and dementia in older adults (Jones et al., 2024; Jia et al., 2020). Additionally, the U-shaped relationship between sleep duration and cognitive impairment risk was particularly evident in hypertensive older adults with higher education level, which suggests that individuals with higher education level might be more vulnerable to cognitive impairment risks associated with both insufficient and excessive sleep. These findings could be explained by cognitive reserve theory (Xu et al., 2015), which proposed that individuals with higher education levels might engage in more cognitively demanding activities, thus increasing their sensitivity to factors that disrupt cognitive resilience such as irregular sleep patterns. However, such interpretation should be treated with caution, and further research is needed to confirm such relationships.

4.4 Strengths and limitations

The main strengths of this study included the large, nationally representative sample and the use of RCS to explore nonlinear relationships between depression, sleep duration and cognitive

impairment. However, several limitations should be noted. First, due to the cross-sectional study design, causal interpretations between depression, sleep duration and cognitive impairment could not be inferred. Second, both depression and sleep duration were based on self-report, which might result in recall bias, and the data in the CLHLS did not differentiate between nighttime sleep and daytime naps. Third, there are other confounding factors related to cognitive impairment (e.g., number and severity of physical comorbidities, hearing loss and air pollution) (Wang et al., 2025) which were not included in the analysis due to numerous missing or unavailable data in the CLHLS. Hence, various relevant risk factors should be included in future research. Fourth, although the data were collected in 2017–2018, the associations identified remain valuable for understanding symptom-level relationships in this population. Future studies are needed to validate these findings. Finally, the definition of hypertension in the Chinese guidelines was $\geq 140/90$ mmHg during the 2017–2018 study period (Liu, 2020), which differed from the 2017 U.S. guideline ($\geq 130/80$ mmHg) (Whelton et al., 2018). This discrepancy might potentially limit direct comparisons with studies based on the international criteria.

5 Conclusion

The results of this study provide novel insights into the association between depression, sleep duration and cognitive impairment among hypertensive older adults. Both depression and suboptimal sleep duration were associated with increased risk of cognitive impairment. Individuals with higher educational levels were more vulnerable to the risk of cognitive impairment linked to irregular sleep patterns. Interventions for managing depressive symptoms and optimizing sleep duration, particularly for those with higher educational backgrounds could address the risk of cognitive impairment in older adults with hypertension.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: <https://doi.org/10.18170/DVN/WBO7LK>.

Ethics statement

The studies involving humans were approved by Peking University Research Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

H-YF: Data curation, Formal analysis, Funding acquisition, Software, Writing – original draft, Writing – review & editing. H-LS:

Formal analysis, Methodology, Writing – review & editing. YF: Funding acquisition, Methodology, Writing – review & editing. QZ: Data curation, Funding acquisition, Writing – review & editing. H-QX: Validation, Writing – original draft. Q-HH: Visualization, Writing – original draft. ZS: Software, Writing – review & editing. TC: Supervision, Writing – review & editing. CN: Conceptualization, Methodology, Supervision, Writing – original draft. Y-TX: Conceptualization, Funding acquisition, Supervision, Writing – original draft, Writing – review & editing. GW: Conceptualization, Funding acquisition, Supervision, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. The study was supported by the Education Department of Hainan Province (Hnjg2024ZC-55), Hainan Medical University Educational Research Project (HYYB202326), Beijing High Level Public Health Technology Talent Construction Project (Discipline Backbone-01-028), the Beijing Municipal Science & Technology Commission (no. Z181100001518005), the Capital's Funds for Health Improvement and Research (CFH 2024-2-1174), and the University of Macau (MYRG2022-00187-FHS and MYRG-GRG2023-00141-FHS).

References

- Albert, S. M. (2019). Sleep duration and cognitive health. *Am. J. Geriatr. Psychiatry* 27, 1397–1398. doi: 10.1016/j.jagp.2019.07.012
- Andresen, E. M., Malmgren, J. A., Carter, W. B., and Patrick, D. L. (1994). Screening for depression in well older adults: evaluation of a short form of the Ces-D. *Am. J. Prev. Med.* 10, 77–84. doi: 10.1016/S0749-3797(18)30622-6
- Bai, W., Zhang, J., Smith, R. D., Cheung, T., Su, Z., Ng, C. H., et al. (2023). Inter-relationship between cognitive performance and depressive symptoms and their association with quality of life in older adults: a network analysis based on the 2017–2018 wave of Chinese longitudinal healthy longevity survey (Clhls). *J. Affect. Disord.* 320, 621–627. doi: 10.1016/j.jad.2022.09.159
- Capone, C., Faraco, G., Peterson, J. R., Coleman, C., Anrather, J., Milner, T. A., et al. (2012). Central cardiovascular circuits contribute to the neurovascular dysfunction in angiotensin ii hypertension. *J. Neurosci.* 32, 4878–4886. doi: 10.1523/JNEUROSCI.6262-11.2012
- Center for Healthy Aging Development Studies (2020). The Chinese longitudinal healthy longevity survey (CLHLS)-longitudinal data (1998–2018). Peking, China: Peking University Open Research Data Platform.
- Chen, H., and Mui, A. C. (2014). Factorial validity of the Center for Epidemiologic Studies Depression Scale short form in older population in China. *Int. Psychogeriatr.* 26, 49–57. doi: 10.1017/S1041610213001701
- Croxford, R. (2016). Restricted cubic spline regression: A brief introduction: Institute for Clinical Evaluative Sciences. 5621–2016.
- Cui, G.-H., Yao, Y.-H., Xu, R.-F., Tang, H.-D., Jiang, G.-X., Wang, Y., et al. (2011). Cognitive impairment using education-based cutoff points for Cmmse scores in elderly Chinese people of agricultural and rural Shanghai China. *Acta Neurol. Scand.* 124, 361–367. doi: 10.1111/j.1600-0404.2010.01484.x
- Deng, Y., Zhao, S., Cheng, G., Yang, J., Li, B., Xu, K., et al. (2021). The prevalence of mild cognitive impairment among Chinese people: a Meta-analysis. *Neuroepidemiology* 55, 79–91. doi: 10.1159/000512597
- Diekelmann, S. (2014). Sleep for cognitive enhancement. *Front. Syst. Neurosci.* 8:46. doi: 10.3389/fnsys.2014.00046
- Ding, R., Ding, P., Tian, L., Kuang, X., Huang, B., and Lin, C. (2024). Associations between sleep duration, depression status, and cognitive function among Chinese elderly: a community-based study. *J. Affect. Disord.* 366, 273–282. doi: 10.1016/j.jad.2024.08.200
- Folstein, M. F., Folstein, S. E., and McHugh, P. R. (1975). Mini-mental state. A practical method for grading the cognitive state of patients for the clinician. *J. Psychiatr. Res.* 12, 189–198.
- Gan, Q., Yu, R., Lian, Z., Yuan, Y., Li, Y., and Zheng, L. (2023). Unraveling the link between hypertension and depression in older adults: a meta-analysis. *Front. Public Health* 11:1302341. doi: 10.3389/fpubh.2023.1302341
- Giannouli, V. (2017). Insomnia-related sleep disruptions, cognition and detailed concurrent anxiety testing during the inter-episode phase of bipolar disorder: a herculean task or a necessity? *J. Psychiatr. Res.* 95, 76–77. doi: 10.1016/j.jpsychires.2017.08.005
- Grandner, M., Mullington Janet, M., Hashmi Sarah, D., Redeker Nancy, S., Watson Nathaniel, F., and Morgenthaler Timothy, I. (2018). Sleep duration and hypertension: analysis of > 700,000 adults by age and sex. *J. Clin. Sleep Med.* 14, 1031–1039. doi: 10.5664/jcsm.7176
- Guo, Y., Pai, M., Xue, B., and Lu, W. (2023). Bidirectional association between depressive symptoms and mild cognitive impairment over 20 years: evidence from the health and retirement study in the United States. *J. Affect. Disord.* 338, 449–458. doi: 10.1016/j.jad.2023.06.046
- Henry, A., Katsoulis, M., Masi, S., Fatemifar, G., Denaxas, S., Acosta, D., et al. (2019). The relationship between sleep duration, cognition and dementia: a Mendelian randomization study. *Int. J. Epidemiol.* 48, 849–860. doi: 10.1093/ije/dyz071
- Huang, W., Zhu, W., Chen, H., Li, F., Huang, J., Zhou, Y., et al. (2022). Longitudinal association between depressive symptoms and cognitive decline among middle-aged and elderly population. *J. Affect. Disord.* 303, 18–23. doi: 10.1016/j.jad.2022.01.107
- Jia, L., Du, Y., Chu, L., Zhang, Z., Li, F., Lyu, D., et al. (2020). Prevalence, risk factors, and management of dementia and mild cognitive impairment in adults aged 60 years or older in China: a cross-sectional study. *Lancet Public Health* 5, e661–e671. doi: 10.1016/S2468-2667(20)30185-7
- Jones, A., Ali, M. U., Kenny, M., Mayhew, A., Mokashi, V., He, H., et al. (2024). Potentially modifiable risk factors for dementia and mild cognitive impairment: an umbrella review and Meta-analysis. *Dement. Geriatr. Cogn. Disord.* 53, 91–106. doi: 10.1159/000536643
- Katzman, R., Zhang, M. Y., Ouangyaqu, S., Wang, Z. Y., Liu, W. T., Yu, E., et al. (1988). A Chinese version of the mini-mental state examination; impact of illiteracy in a Shanghai dementia survey. *J. Clin. Epidemiol.* 41, 971–978.
- Kielbasa, G., Stolarz-Skrzypek, K., Pawlik, A., Łatka, M., Drożdż, T., Olszewska, M., et al. (2016). Assessment of sleep disorders among patients with hypertension and coexisting metabolic syndrome. *Adv. Med. Sci.* 61, 261–268. doi: 10.1016/j.advms.2016.03.005
- Kohn, J. N., Troyer, E., Guay-Ross, R. N., Wilson, K., Walker, A., Spoon, C., et al. (2020). Self-reported sleep disturbances are associated with poorer cognitive performance in older adults with hypertension: a multi-parameter risk factor investigation. *Int. Psychogeriatr.* 32, 815–825. doi: 10.1017/S1041610219001492

Acknowledgments

The authors are grateful to all participants and clinicians involved in this study.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

- Kraynak, T. E., and Andreescu, C. (2022). Pathways linking hypertension and depression with mild cognitive impairment in older adults. *Int. Psychogeriatr.* 34, 515–517. doi: 10.1017/S1041610222000278
- Lawton, M. P., and Brody, E. M. (1969). Assessment of older people: self-maintaining and instrumental activities of daily living. *Gerontologist* 9, 179–186. doi: 10.1093/geront/9.3_Part_1.179
- Li, M., Wang, N., and Dupre, M. E. (2022). Association between the self-reported duration and quality of sleep and cognitive function among middle-aged and older adults in China. *J. Affect. Disord.* 304, 20–27. doi: 10.1016/j.jad.2022.02.039
- Liang, F., Fu, J., Turner-McGrievy, G., Wang, Y., Qiu, N., Ding, K., et al. (2022). Association of body mass index and plant-based diet with cognitive impairment among older Chinese adults: a prospective, nationwide cohort study. *Nutrients* 14:3132. doi: 10.3390/nu14153132
- Liu, J. (2020). Highlights of the 2018 Chinese hypertension guidelines. *Clin Hypertens* 26:8. doi: 10.1186/s40885-020-00141-3
- Liu, Z., Su, Y., Huang, R., Li, R., Wei, Z., He, L., et al. (2023). Depression trajectories, genetic risk, and cognitive performance in older adults: multilevel model with a 10-year longitudinal cohort. *Gerontology* 69, 899–909. doi: 10.1159/000530200
- Liu, W., Wu, Q., Wang, M., Wang, P., and Shen, N. (2022). Prospective association between sleep duration and cognitive impairment: findings from the China health and retirement longitudinal study (Charls). *Front. Med.* 9:510. doi: 10.3389/fmed.2022.971510
- Lo, J. C., Groeger, J. A., Cheng, G. H., Dijk, D.-J., and Chee, M. W. L. (2016). Self-reported sleep duration and cognitive performance in older adults: a systematic review and meta-analysis. *Sleep Med.* 17, 87–98. doi: 10.1016/j.sleep.2015.08.021
- Lv, X., Li, W., Ma, Y., Chen, H., Zeng, Y., Yu, X., et al. (2019). Cognitive decline and mortality among community-dwelling Chinese older people. *BMC Med.* 17, 1–10. doi: 10.1186/s12916-019-1295-8
- Ma, Y., Liang, L., Zheng, F., Shi, L., Zhong, B., and Xie, W. (2020). Association between sleep duration and cognitive decline. *JAMA Netw. Open* 3:e2013573. doi: 10.1001/jamanetworkopen.2020.13573
- Martinez-Lemus, L. A., Hill, M. A., and Meininger, G. A. (2009). The plastic nature of the Vascular Wall: a continuum of remodeling events contributing to control of arteriolar diameter and structure. *Physiology* 24, 45–57. doi: 10.1152/physiol.00029.2008
- Muhammad, T., and Meher, T. (2021). Association of late-life depression with cognitive impairment: evidence from a cross-sectional study among older adults in India. *BMC Geriatr.* 21:364. doi: 10.1186/s12877-021-02314-7
- Pepin, J.-L., Borel, A.-L., Tamisier, R., Baguet, J.-P., Levy, P., and Dauvilliers, Y. (2014). Hypertension and sleep: overview of a tight relationship. *Sleep Med. Rev.* 18, 509–519. doi: 10.1016/j.smrv.2014.03.003
- Pires, P. W., Jackson, W. F., and Dorrance, A. M. (2015). Regulation of myogenic tone and structure of parenchymal arterioles by hypertension and the mineralocorticoid receptor. *Am. J. Phys. Heart Circ. Phys.* 309, H127–H136. doi: 10.1152/ajpheart.00168.2015
- Qin, J., He, Z., Wu, L., Wang, W., Lin, Q., Lin, Y., et al. (2021). Prevalence of mild cognitive impairment in patients with hypertension: a systematic review and meta-analysis. *Hypertens. Res.* 44, 1251–1260. doi: 10.1038/s41440-021-00704-3
- R Development Core Team (2020). R: A language and environment for statistical computing. Vienna, Australia: R Foundation for Statistical Computing.
- Rodda, J., Walker, Z., and Carter, J. (2011). Depression in older adults. *BMJ* 343:d5219. doi: 10.1136/bmj.d5219
- Sabia, S., Fayosse, A., Dumurgier, J., Van Hees, V. T., Paquet, C., Sommerlad, A., et al. (2021). Association of sleep duration in middle and old age with incidence of dementia. *Nat. Commun.* 12:2289. doi: 10.1038/s41467-021-22354-2
- Scuteri, A., Nilsson, P. M., Tzourio, C., Redon, J., and Laurent, S. (2011a). Microvascular brain damage with aging and hypertension: pathophysiological consideration and clinical implications. *J. Hypertens.* 29, 1469–1477. doi: 10.1097/HJH.0b013e328347cc17
- Scuteri, A., Spazzafumo, L., Cipriani, L., Gianni, W., Corsonello, A., Cravello, L., et al. (2011b). Depression, hypertension, and comorbidity: disentangling their specific effect on disability and cognitive impairment in older subjects. *Arch. Gerontol. Geriatr.* 52, 253–257. doi: 10.1016/j.archger.2010.04.002
- Sierksma, A. S. R., Van Den Hove, D. L. A., Steinbusch, H. W. M., and Prickaerts, J. (2010). Major depression, cognitive dysfunction and Alzheimer's disease: is there a link? *Eur. J. Pharmacol.* 626, 72–82. doi: 10.1016/j.ejphar.2009.10.021
- Song, Y., Liu, H., Gu, K., and Liu, Y. (2024). Association between nighttime sleep duration, nap time, and mild cognitive impairment in Chinese older adults: a cross-sectional study. *BMC Public Health* 24:2381. doi: 10.1186/s12889-024-19900-0
- Suh, S. W., Han, J. W., Lee, J. R., Byun, S., Kwon, S. J., Oh, S. H., et al. (2018). Sleep and cognitive decline: a prospective nondemented elderly cohort study. *Ann. Neurol.* 83, 472–482. doi: 10.1002/ana.25166
- Tan, S., Liu, D., Zhang, Y., Li, S., Zhang, K., and Zuo, H. (2023). Trends in blood pressure and hypertension among older adults and oldest-old individuals in China between 2008–2018. *Hypertens. Res.* 46, 1145–1156. doi: 10.1038/s41440-023-01183-4
- Tong, A. Y., and Man, D. W. (2002). The validation of the Hong Kong Chinese version of the Lawton instrumental activities of daily living scale for institutionalized elderly persons. *OTJR Occup. Ther. J. Res.* 22, 132–142. doi: 10.1177/153944920202200402
- Uchmanowicz, I., Markiewicz, K., Uchmanowicz, B., Koltuniuk, A., and Rosińczuk, J. (2019). The relationship between sleep disturbances and quality of life in elderly patients with hypertension. *Clin. Interv. Aging* 14, 155–165. doi: 10.2147/CIA.S188499
- Ungvari, Z., Toth, P., Tarantini, S., Prodan, C. I., Sorond, F., Merkely, B., et al. (2021). Hypertension-induced cognitive impairment: from pathophysiology to public health. *Nat. Rev. Nephrol.* 17, 639–654. doi: 10.1038/s41581-021-00430-6
- Wang, M., Fan, C., Han, Y., Wang, Y., Cai, H., Zhong, W., et al. (2025). Associations of modifiable dementia risk factors with dementia and cognitive decline: evidence from three prospective cohorts. *Front. Public Health* 13:1529969. doi: 10.3389/fpubh.2025.1529969
- Wang, Z., Wang, S., Lin, H., Wang, C., and Gao, D. (2024). Prevalence of hypertension and related risk factors in older Chinese population: a meta-analysis. *Front. Public Health* 12:295. doi: 10.3389/fpubh.2024.130295
- Warsame, F., Chu, N. M., Hong, J., Mathur, A., Crews, D. C., Bayliss, G., et al. (2023). Sleep duration and cognitive function among older adults with chronic kidney disease: results from the National Health and nutrition examination survey (2011–2014). *Nephrol Dial Transplant* 38, 1636–1644. doi: 10.1093/ndt/gfac325
- Wei, J., Ying, M., Xie, L., Chandrasekar, E. K., Lu, H., Wang, T., et al. (2019). Late-life depression and cognitive function among older adults in the U.S.: the National Health and nutrition examination survey, 2011–2014. *J. Psychiatr. Res.* 111, 30–35. doi: 10.1016/j.jpsychires.2019.01.012
- Whelton, P. K., Carey, R. M., Aronow, W. S., Casey, D. E., Collins, K. J., Dennison Himmelfarb, C., et al. (2018). 2017 Acc/Aha/Aapa/Abc/Acpm/Ags/Apha/ash/Aspc/Nma/Pcna guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association task force on clinical practice guidelines. *Hypertension* 71, e13–e115. doi: 10.1161/HYP.0000000000000065
- Wigren, H.-K., and Stenberg, T. (2015). How does sleeping restore our brain? *Duodecim* 131, 151–156.
- Wu, J., Song, X., Chen, G.-C., Neelakantan, N., Van Dam, R. M., Feng, L., et al. (2019). Dietary pattern in midlife and cognitive impairment in late life: a prospective study in Chinese adults. *Am. J. Clin. Nutr.* 110, 912–920. doi: 10.1093/ajcn/nqz150
- Wu, L., Sun, D., and Tan, Y. (2018). A systematic review and dose-response meta-analysis of sleep duration and the occurrence of cognitive disorders. *Sleep Breath* 22, 805–814. doi: 10.1007/s11325-017-1527-0
- Wu, X., Zhang, N., Chao, J., Liu, Y., and Zhang, B. (2024). Sex-specific in the association between depressive symptoms and risk of cognitive impairment in Chinese older adults. *Arch. Psychiatr. Nurs.* 52, 69–75. doi: 10.1016/j.apnu.2024.07.012
- Xu, W., Yu, J.-T., Tan, M.-S., and Tan, L. (2015). Cognitive reserve and Alzheimer's disease. *Mol. Neurobiol.* 51, 187–208. doi: 10.1007/s12035-014-8720-y
- Yang, J., Zhang, Y., Shen, S., Yu, H., Yang, L., Zhao, Y., et al. (2023). Instrumental activities of daily living trajectories and risk of mild cognitive impairment among Chinese older adults: results of the Chinese longitudinal healthy longevity survey, 2002–2018. *Front. Public Health* 11:1165753. doi: 10.3389/fpubh.2023.1165753
- Yao, L., Ni, J., Wei, M., Li, T., Long, Z., Shi, J., et al. (2024). Association of Depression and Cognitive Performance in us older adults: a secondary analysis of cross-sectional data using Nhanes 2013–2014. *Eur. Neurol.* 87, 147–158. doi: 10.1159/000540277
- Yena, L., Khrystoporova, G., Garkavenko, O., Kuprash, O., and Bevzyuk, L. (2024). Cognitive and depressive disorders in older hypertensive patients. *Ageing Longev.* 5, 97–104. Available at: <http://aging-longevity.org.ua/journal-description/article/view/134>
- Yin, J., John, A., and Cadar, D. (2024). Bidirectional associations of depressive symptoms and cognitive function over time. *JAMA Netw. Open* 7:e2416305. doi: 10.1001/jamanetworkopen.2024.16305
- Yu, X., Zhang, W., and Kobayashi, L. C. (2021). Duration of poverty and subsequent cognitive function and decline among older adults in China, 2005–2018. *Neurology* 97:e739–e746. doi: 10.1212/WNL.00000000000012343
- Zeki Al Hazzouri, A., Vittinghoff, E., Byers, A., Covinsky, K., Blazer, D., Diem, S., et al. (2014). Long-term cumulative depressive symptom burden and risk of cognitive decline and dementia among very old women. *J. Gerontol. Ser. A* 69, 595–601. doi: 10.1093/gerona/glt139
- Zeng, Y., Feng, Q., Hesketh, T., Christensen, K., and Vaupel, J. W. (2017). Survival, disabilities in activities of daily living, and physical and cognitive functioning among the oldest-old in China: a cohort study. *Lancet* 389, 1619–1629. doi: 10.1016/S0140-6736(17)30548-2
- Zhang, M., Lv, X., Chen, Y., Tu, L., Fan, Z., Yao, Y., et al. (2022). Excessive sleep increased the risk of incidence of cognitive impairment among older Chinese adults: a cohort study based on the Chinese longitudinal healthy longevity survey (Clhls). *Int. Psychogeriatr.* 34, 725–734. doi: 10.1017/S1041610221000168
- Zheng, Z. (2020). Twenty years' follow-up on elder people's health and quality of life. *China Popul. Dev. Stud.* 3, 297–309. doi: 10.1007/s42379-020-00045-7
- Zhou, X., Li, J., Yu, C., Fang, W., Xie, Y., Wang, L., et al. (2022). Sex modified the association between sleep duration and worse cognitive performance in Chinese hypertensive population: insight from the China H-type hypertension registry study. *Behav. Neurol.* 2022, 1–8. doi: 10.1155/2022/7566033
- Zhou, L., Ma, X., and Wang, W. (2021). Relationship between cognitive performance and depressive symptoms in Chinese older adults: the China health and retirement longitudinal study (Charls). *J. Affect. Disord.* 281, 454–458. doi: 10.1016/j.jad.2020.12.059