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Exploring the Relationship Between Hearing Impairment and Low Back Pain in Chinese Middle-Aged and Older Adults: The Mediating Role of Depressive Symptoms

Huoliang Cao
Fujian University of Traditional Chinese Medicine
Yanyan Lin
Fujian University of Traditional Chinese Medicine
Yang Hu
Fujian University of Traditional Chinese Medicine
Rufeng Wu
Fujian University of Traditional Chinese Medicine
Juan Chen
Fujian University of Traditional Chinese Chinese Medicine
Jingyan Wu
Fujian University of Traditional Chinese Medicine
Shu Jiang
js369@163.com
Fujian University of Traditional Chinese Medicine
Yanzhen Zhu
Fujian University of Traditional Chinese Medicine

Article

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Abstract

Background

Hearing impairment and low back pain are both common in middle-aged and older adults and are associated with poorer function and quality of life. However, longitudinal evidence on whether hearing impairment is associated with subsequent low back pain in Chinese middle-aged and older adults remains limited. Depressive symptoms may represent one pathway linking hearing impairment to later pain outcomes.

Methods

Using longitudinal data from the China Health and Retirement Longitudinal Study from 2011 to 2018, we included 9,650 participants aged 45 years and older who were free of low back pain at baseline. Hearing impairment was assessed using self-reported hearing status and hearing aid use. Low back pain was identified during follow-up based on self-reported bodily pain located in the lower back. Depressive symptoms were assessed at baseline using the CES-D-10. Multivariable logistic regression and mediation analyses were performed after adjustment for demographic factors, lifestyle factors, and chronic conditions.

Results

During the 7-year follow-up period, 3,101 participants developed low back pain. Hearing impairment was associated with a higher risk of low back pain in the unadjusted model, with an odds ratio of 1.28 and a 95% confidence interval of 1.18 to 1.40. This association remained significant after multivariable adjustment and persisted in the fully adjusted model, with an odds ratio of 1.13 and a 95% confidence interval of 1.03 to 1.24. Mediation analysis indicated that depressive symptoms partially mediated this association, accounting for 18.1% of the total effect.

Conclusion

In this longitudinal study of Chinese middle-aged and older adults, hearing impairment was associated with subsequent low back pain, and baseline depressive symptoms partially mediated this association. These findings support the importance of considering sensory health and mental health together when evaluating pain risk in ageing populations.

1. Introduction

Hearing impairment is a common sensory disorder and an increasingly important public health concern in ageing populations. Global estimates from the Global Burden of Disease Study 2019 indicate that hearing loss affects a substantial proportion of the population worldwide and contributes notably to years lived with disability [1]. In older adults, the burden of hearing loss rises sharply with age. In a nationally representative sample of United States Medicare beneficiaries aged 71 years and older, hearing loss was highly prevalent, and the prevalence increased further among those aged 90 years and older [2]. In China, hearing loss is also common among adults aged 45 years and older, highlighting the need to better understand its broader health consequences in middle-aged and older populations [3, 4].

Low back pain is one of the most common musculoskeletal symptoms in later life and remains a major contributor to disability worldwide [5]. The Lancet series on low back pain has emphasized that this condition is not only highly prevalent but also difficult to prevent and manage effectively at the population level [5, 6]. In older adults, the burden of low back pain is particularly pronounced. Previous reviews have shown that its prevalence in older populations ranges widely, reflecting both substantial disease burden and heterogeneity across settings [7, 8]. In addition to restricting daily activities

and mobility, low back pain is also associated with poorer function, greater health care use, and reduced quality of life in later life [9]. In China, chronic pain is highly prevalent among middle-aged and older adults, and low back pain is among the most frequently reported pain sites [10, 11].

Emerging evidence suggests that hearing impairment may be related to pain-related outcomes, although direct evidence remains limited. A study of middle-aged and older Korean adults reported that age-related hearing loss, particularly when accompanied by tinnitus, was associated with chronic low back pain [12]. Hearing impairment has also been linked to poorer mental health in Chinese middle-aged and older adults. Prior studies based on Chinese population data have shown that self-reported hearing loss is associated with depressive symptoms, and longitudinal analyses suggest that sensory loss and depressive symptoms may be linked in both directions [13–15]. In addition, psychosocial pathways such as social isolation and loneliness may partly explain the relationship between hearing loss and depression among older adults in China [16, 17]. A recent meta-analysis further supported an overall association between hearing loss and depression in older adults [18].

Because depressive symptoms are closely related to pain perception, pain persistence, and pain-related disability, they may help explain part of the association between hearing impairment and later low back pain. However, longitudinal evidence on this potential pathway remains scarce, especially in Chinese middle-aged and older adults. Using data from the China Health and Retirement Longitudinal Study, the present study aimed to examine the longitudinal association between hearing impairment and incident low back pain in Chinese adults aged 45 years and older and to further explore whether baseline depressive symptoms, assessed by the CES-D-10, partially mediate this association.

2. Methods

2.1 Study design and participants

This study was based on data from the China Health and Retirement Longitudinal Study, a nationally representative longitudinal survey of Chinese adults aged 45 years and older and their spouses [19]. The baseline survey was conducted in 2011, and participants were followed up biennially thereafter [19]. The present study also followed the Strengthening the Reporting of Observational Studies in Epidemiology reporting framework for observational research [20].

We used 2011 as the baseline and followed participants through 2018. Participants were excluded if they were younger than 45 years, had missing information on hearing status, had missing data on depressive symptoms, lacked information on low back pain at baseline or follow-up, or reported low back pain at baseline. After these exclusions, 9,650 participants were included in the final analytic sample.

The original CHARLS study was approved by the Institutional Review Board of Peking University, and written informed consent was obtained from all participants before data collection[19]. The present study was a secondary analysis of de-identified publicly available data.

2.2 Assessment of hearing impairment

Hearing impairment was assessed using self-reported hearing function in CHARLS. Participants were asked whether they had ever worn a hearing aid and how they would rate their hearing as excellent, very good, good, fair, or poor. Consistent with previous studies using Chinese population data, participants were classified as having hearing impairment if they reported hearing aid use or rated their hearing as fair or poor [3, 13]. Because this definition was based on self-report rather than audiometric testing, the exposure in the present study should be interpreted as self-reported hearing impairment.

2.3 Assessment of low back pain

Low back pain was the outcome variable in this study. During the CHARLS household interview, participants were first asked whether they were often troubled by bodily pain. Those who answered yes were then asked to identify the location of the pain from a list of body regions. Participants who reported bodily pain and identified the lower back as the pain site during follow-up were classified as having low back pain. Because this measure was based on self-report, the present study focused on self-reported low back pain rather than clinically confirmed chronic low back pain.

2.4 Assessment of depressive symptoms

Depressive symptoms were assessed at baseline using the 10-item Center for Epidemiologic Studies Depression Scale. The CES-D-10 has been widely used as a brief screening instrument in older adults, including Chinese populations [21–23]. Total scores range from 0 to 30, with higher scores indicating more severe depressive symptoms. In the present study, the baseline CES-D-10 score was used in the additional adjustment model and in the mediation analysis. For descriptive purposes, a score of 10 or higher was used to indicate clinically relevant depressive symptoms, consistent with prior applications of the CES-D-10 in older populations [24, 25].

2.5 Covariates

Potential covariates were selected based on the original dataset structure and prior CHARLS-based research. These included age, sex, residence, educational level, marital status, smoking status, drinking status, sleep duration, body mass index, hypertension, and diabetes. Body mass index was calculated as weight in kilograms divided by height in meters squared. Hypertension and diabetes were defined using self-reported physician diagnosis and relevant biomarker or blood pressure thresholds consistent with the CHARLS protocol.

2.6 Statistical analysis

Categorical variables are presented as numbers and percentages, and continuous variables are presented as medians with interquartile ranges, consistent with the original tables. Baseline characteristics were compared between participants with and without hearing impairment using the chi-square test for categorical variables and the t test or Wilcoxon rank-sum test for continuous variables, as appropriate.

Multivariable logistic regression was used to estimate the association between hearing impairment and low back pain over the follow-up period. Model 1 was unadjusted. Model 2 was adjusted for age, sex, residence, and education. Model 3 was further adjusted for body mass index, sleep duration, smoking, drinking, hypertension, and diabetes. Model 4 additionally included baseline CES-D-10 score.

To examine whether depressive symptoms partially mediated the association between hearing impairment and low back pain, causal mediation analysis was conducted using a counterfactual framework [26] and the mediation package in R [27]. Nonparametric bootstrap resampling with 1,000 simulations was used to estimate the average causal mediation effect, the average direct effect, and the proportion mediated. All analyses were performed using R version 4.4.2, and a two-sided P value of less than 0.05 was considered statistically significant.

3. Results

3.1 Baseline characteristics

A total of 9,650 participants were included in the final analysis. Among them, 4,708 were classified as having no hearing impairment and 4,942 were classified as having hearing impairment. Significant between-group differences were observed in age, sleep duration, CES-D-10 score, marital status, education level, place of residence, drinking status, smoking status, hypertension, diabetes, and depressive symptoms. In general, participants with hearing impairment tended to be older, had shorter sleep duration, and had higher depressive symptom scores. The detailed baseline characteristics are shown in Table 1.

Table 1
Baseline characteristics of the study population by hearing impairment

Age, years	**Total (n = 9650)**	**No hearing impairment (n = 4708)**	**Hearing impairment (n = 4942)**	**p**
	57 (51, 64)	**56 (50, 62)**	**59 (53, 66)**	**< 0.001**
Sleeptime	7 (5, 8)	7 (6, 8)	6 (5, 8)	< 0.001
BMI, kg/m2	23.22 (21.01, 25.81)	23.3 (21.14, 25.89)	23.16 (20.9, 25.74)	0.05
CESD-10 scores	6 (3, 11)	5 (2, 9)	7 (3, 12)	< 0.001
Sex, n (%)				0.389
Female	4937 (51.16)	2387 (50.7)	2550 (51.6)	
Male	4713 (48.84)	2321 (49.3)	2392 (48.4)	
Marriage status, n (%)				0.002
Others	1036 (10.74)	457 (9.71)	579 (11.72)	
Married	8614 (89.26)	4251 (90.29)	4363 (88.28)	
Educational level, n (%)				< 0.001
No formal education	4125 (42.79)	1838 (39.07)	2287 (46.34)	
Primary school	2109 (21.88)	1007 (21.41)	1102 (22.33)	
Middle school	2133 (22.13)	1113 (23.66)	1020 (20.67)	
High school or above	1272 (13.2)	746 (15.86)	526 (10.66)	
Residence, n (%)				< 0.001
Urban	3748 (38.84)	1974 (41.93)	1774 (35.9)	
Rural	5902 (61.16)	2734 (58.07)	3168 (64.1)	
Drinking, n (%)				< 0.001
Former	717 (7.43)	303 (6.44)	414 (8.38)	
Current	3276 (33.96)	1644 (34.93)	1632 (33.04)	
Never	5653 (58.6)	2759 (58.63)	2894 (58.58)	
Smoking, n (%)				< 0.001
Former	776 (8.04)	317 (6.73)	459 (9.29)	
Current	3021 (31.31)	1507 (32.02)	1514 (30.64)	
Never	5852 (60.65)	2883 (61.25)	2969 (60.08)	
Hypertension, n (%)				< 0.001

Age, years	Total (n = 9650)	No hearing impairment (n = 4708)	Hearing impairment (n = 4942)	p
	57 (51, 64)	**56 (50, 62)**	**59 (53, 66)**	**< 0.001**
No	5371 (55.83)	2751 (58.53)	2620 (53.24)	
Yes	4250 (44.17)	1949 (41.47)	2301 (46.76)	
Diabetes, n (%)				0.029
No	8480 (88.6)	4172 (89.34)	4308 (87.9)	
Yes	1091 (11.4)	498 (10.66)	593 (12.1)	
Depressive symptoms, n (%)				< 0.001
No	6784 (70.3)	3627 (77.04)	3157 (63.88)	
Yes	2866 (29.7)	1081 (22.96)	1785 (36.12)	

3.2 Longitudinal association between hearing impairment and low back pain

During the 7-year follow-up period, 3,101 participants developed low back pain. Compared with participants without hearing impairment, those with hearing impairment had a significantly higher risk of developing low back pain in the unadjusted model, with an odds ratio of 1.28 and a 95% confidence interval of 1.18 to 1.40. After adjustment for age, sex, residence, and education, the association remained significant. Further adjustment for body mass index, sleep duration, smoking, drinking, hypertension, and diabetes did not materially change the results. After additional adjustment for baseline CES-D-10 score, hearing impairment remained significantly associated with low back pain, with an odds ratio of 1.13 and a 95% confidence interval of 1.03 to 1.24. The detailed regression results are shown in Table 2.

Table 2
Association between hearing impairment and low back pain

Variables	Model1		Model2		Model3		Model4	
	OR (95%CI)	**P**	**OR (95%CI)**	**P**	**OR (95%CI)**	**P**	**OR (95%CI)**	**P**
HI								
No	1.00 (Reference)		1.00 (Reference)		1.00 (Reference)		1.00 (Reference)	
Yes	1.28 (1.18 ~ 1.40)	< .001	1.27 (1.17 ~ 1.39)	< .001	1.23 (1.13 ~ 1.35)	< .001	1.13 (1.03 ~ 1.24)	0.008
OR: Odds Ratio, CI: Confidence Interval								

Model 1: No adjustment.

Model 2: Adjusted according to age, gender, place of residence, and education level.

Model 3: Adjusted according to age, gender, place of residence, education level, body mass index, sleep time, smoking status, drinking status, and chronic medical history (diabetes, hypertension).

Model 4: Adjusted according to age, gender, place of residence, education level, body mass index, sleep time, smoking status, drinking status, chronic medical history (diabetes, hypertension), and CESD-10 score .

3.3 Subgroup analysis

Subgroup analyses were conducted across strata of age, sex, residence, educational level, marital status, smoking status, drinking status, hypertension, diabetes, sleep duration, body mass index, and depressive symptoms. No statistically significant interaction was observed across the examined subgroups, suggesting that the positive association between hearing impairment and low back pain was generally consistent across participant characteristics. The subgroup results are shown in Fig. 2.

Confounders for age, gender, residence, education level, BMI, sleep duration, smoking status, drinking status, and history of chronic diseases (diabetes, hypertension) and depressive symptom scores in multivariate models.

3.4 Mediation analysis

Mediation analysis showed that baseline depressive symptoms partially mediated the association between hearing impairment and low back pain. The average causal mediation effect was 0.00588, the average direct effect was 0.02648, and the proportion mediated was 18.1 percent. These findings suggest that depressive symptoms accounted for part, but not all, of the association between hearing impairment and later low back pain. The detailed mediation results are shown in Table 3.

Table 3
Mediation of the association between hearing impairment and low back pain by baseline CES-D-10 score

Effect	Estimate	95% CI Lower	95% CI Upper	P-value
ACME (average)	0.00588	0.00403	0.01	< 0.001 ***
ADE (average)	0.02648	0.00756	0.04	0.004 **
Prop. Mediated (average)	0.18138	0.09872	0.46	< 0.001 ***

4. Discussion

In this longitudinal study of Chinese middle-aged and older adults, hearing impairment was associated with a higher risk of subsequent low back pain. The association remained significant after adjustment for demographic characteristics, lifestyle factors, and chronic conditions. It also persisted after additional adjustment for baseline depressive symptoms. Mediation analysis further suggested that baseline depressive symptoms partially mediated this association, accounting for 18.1 percent of the total effect.

Our main finding is consistent with the limited direct evidence linking hearing loss and low back pain. In Korean middle-aged and older adults, age-related hearing loss with tinnitus was associated with chronic low back pain [12]. In addition, nationally representative data from China indicate that chronic pain is highly prevalent in middle-aged and older adults, and sensory and psychological factors may coexist within this broader burden of pain [10]. Taken together, these findings support the plausibility of a relationship between hearing impairment and low back pain in later life.

Several pathways may help explain why hearing impairment is associated with low back pain. First, hearing impairment may be linked to poorer physical functioning and reduced movement. In community-dwelling older adults, hearing impairment has been associated with poorer physical functioning and lower total movement activity [28, 29]. A recent systematic review and meta-analysis also reported that greater hearing impairment is associated with poorer postural stability and mobility-related performance in older adults [30]. Consistent with this, prior studies have linked hearing impairment with frailty, falls, slower gait speed, increased gait variability, and broader functional limitations [31–35]. These findings suggest that hearing impairment may contribute to reduced mobility, poorer balance, and lower physical reserve, all of which may increase vulnerability to pain-related disability, including low back pain.

Second, hearing impairment may be related to musculoskeletal vulnerability. Prior work has suggested that hearing loss is associated with sarcopenia in middle-aged and older adults, including evidence from Chinese and Korean populations [36, 37]. Some studies have also reported associations between hearing loss and lower bone mineral density or osteoporosis-related indicators[38, 39]. Although these pathways do not establish causality, they suggest that hearing impairment may coexist with broader age-related changes in physical health that could increase susceptibility to low back pain.

Third, depressive symptoms may help explain part of the observed association. Longitudinal and cross-sectional studies in Chinese older adults have shown that hearing impairment is associated with a higher risk of depressive symptoms [13–17]. Previous work has also suggested that depressive symptoms are closely intertwined with pain and pain-related outcomes. Longitudinal evidence indicates that chronic low back pain is associated with later depression or anxiety symptoms, and broader evidence supports a bidirectional relationship between pain and mental illness [40, 41]. In a Japanese population-based study, low back pain was also associated with psychological stress responses [42]. In mainland China, a meta-analysis identified several psychological risk and protective factors associated with depression in older adults, reinforcing the importance of emotional vulnerability in later life [43]. Together, these findings support the idea that depressive symptoms may represent one clinically relevant pathway connecting hearing impairment to later low back pain.

Psychosocial mechanisms may also contribute to this pathway. Hearing loss is often accompanied by reduced social participation, loneliness, and diminished perceived social support[16, 17]. Loneliness in older adults has been shown to develop over long periods and is closely linked to vulnerability in later life [44]. Intervention studies targeting older adults with hearing loss have similarly emphasized the role of social connectedness and functional fitness [45]. More broadly, older adults with combined sensory impairments tend to have worse functional and psychosocial outcomes [46]. Untreated hearing loss has also been associated with loneliness, emotional distress, and poorer psychosocial well-being[47]. In addition, hearing loss and tinnitus may jointly contribute to depressive symptoms[48]. These findings are compatible with our mediation results and suggest that the psychosocial burden of hearing impairment may be one mechanism through which pain risk increases over time.

The clinical implications of these findings should be interpreted cautiously. Our data do not show that improving hearing will necessarily prevent low back pain. However, they do support a more integrated approach to the assessment of sensory health, mental health, and pain in older adults. Randomized evidence from rural China has shown that providing hearing aids can improve several health-related outcomes among middle-aged and older adults with hearing loss[28]. Other studies have reported that hearing aid use is associated with lower mortality and that hearing restorative devices may be associated with cognitive benefits[29, 30]. While these findings do not directly address low back pain, they suggest that hearing health may have broader relevance for healthy ageing.

This study has several strengths. It was based on a large, nationally representative longitudinal cohort, used prospective follow-up, and incorporated a mediation framework to examine a plausible explanatory pathway. At the same time, several limitations should be acknowledged. First, hearing impairment and low back pain were both assessed by self-report, which may have introduced misclassification. Second, depressive symptoms were measured at baseline in the mediation framework, which limits firm temporal interpretation of the mediator. Third, as an observational study, the analysis cannot establish causality, and residual confounding remains possible. Fourth, low back pain was not clinically diagnosed, so the findings should be interpreted as relating to self-reported low back pain rather than confirmed chronic low back pain. Finally, although hearing rehabilitation and broader biopsychosocial interventions may be promising, further prospective and interventional studies are needed to clarify whether modifying hearing status or psychosocial functioning can reduce later pain risk[45, 49].

5. Conclusions

In summary, this study provides evidence that hearing impairment is associated with subsequent low back pain among Chinese middle-aged and older adults, and that baseline depressive symptoms partially mediate this association. These findings highlight the importance of considering sensory health and mental health together when evaluating pain risk in ageing populations. Future studies should incorporate objective hearing assessment, more detailed pain phenotyping, and repeated measurement of depressive symptoms to clarify the mechanisms underlying these associations.

Abbreviations

HI
Hearing impairment
LBP
Low back pain
CHARLS
China Health and Retirement Longitudinal Study
CES-D-10
10-item Center for Epidemiologic Studies Depression Scale
BMI
Body mass index
OR
Odds ratio
CI
Confidence interval
ACME
Average causal mediation effect
ADE
Average direct effect
STROBE
Strengthening the Reporting of Observational Studies in Epidemiology

Declarations

Ethics approval and consent to participate

The original CHARLS study was approved by the Institutional Review Board of Peking University, and written informed consent was obtained from all participants before data collection. The present study was a secondary analysis of de-identified publicly available data.

Clinical trial number

Not applicable.

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Author Contribution

H.C., Y.L. and Y.H. contributed equally to this work and share first authorship. H.C., Y.L. and Y.H. contributed to conceptualization, methodology, formal analysis, data interpretation, and writing of the original draft. R.W., J.C. and J.W. contributed to data curation, methodology, and review and editing of the manuscript. S.J. and Y.Z. contributed to conceptualization, supervision, interpretation of the results, and critical revision of the manuscript. All authors read and approved the final manuscript.

Data Availability

The data used in this study are available from the China Health and Retirement Longitudinal Study (CHARLS). The datasets are publicly available to registered users through the CHARLS official website.

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Figures

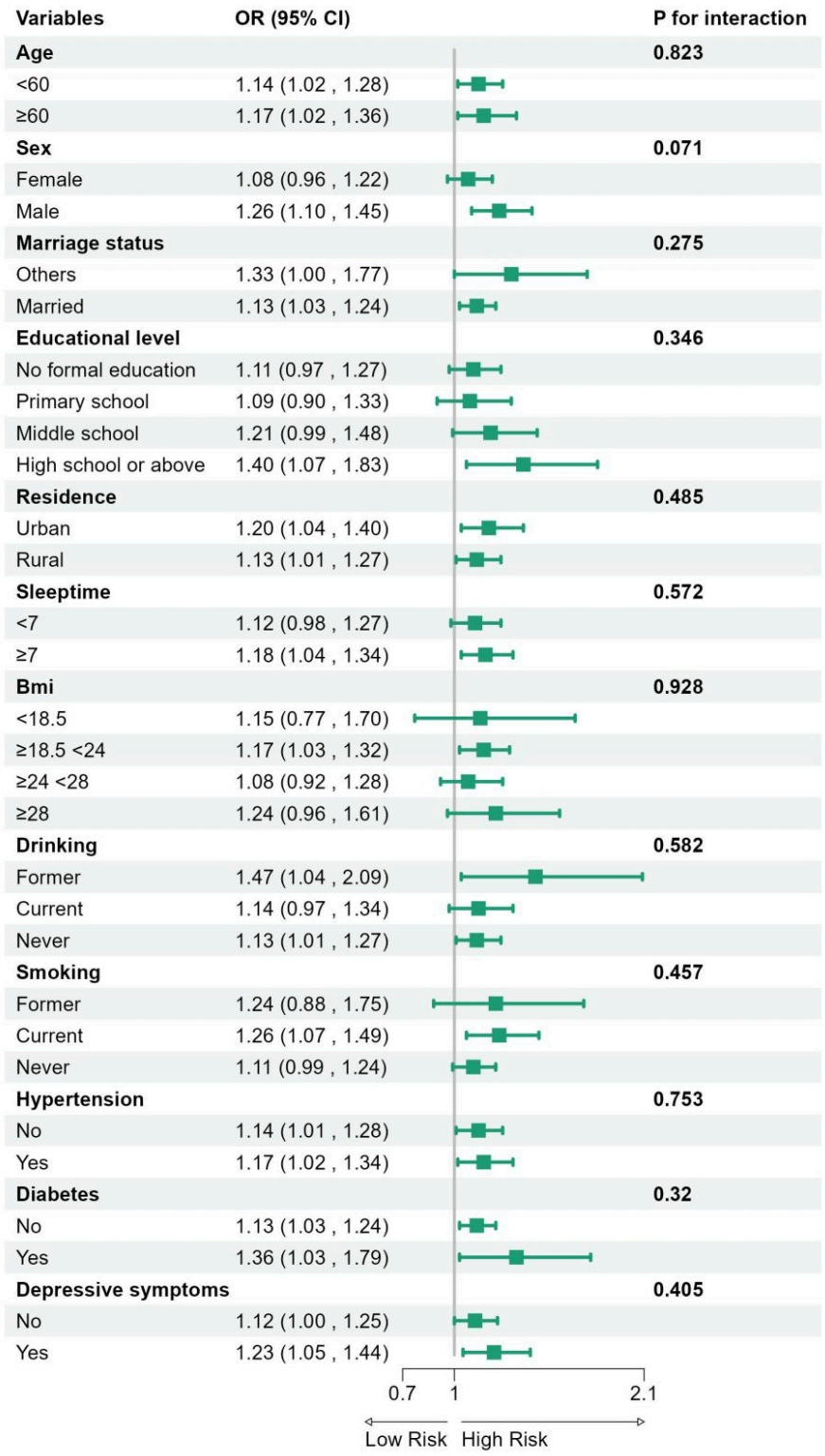


Figure 1

Forest plot of stratified analysis of the association of HI and LBP.

Confounders for age, gender, residence, education level, BMI, sleep duration, smoking status, drinking status, and history of chronic diseases (diabetes, hypertension) and depressive symptom scores in multivariate models.