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Shared Modifiable Risk Factors for Chronic Tinnitus and Alzheimer's Disease: A Mendelian Randomization and Clinical Phenotyping Study

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ABSTRACT

Background: Hearing loss is recognized as the single largest modifiable risk factor for Alzheimer's disease (AD), yet the cognitive implications of chronic tinnitus—a frequent auditory phantom percept—remain largely unexplored. This study aims to identify whether risk factors for tinnitus overlap with those for AD, and whether decompensated tinnitus reflects a heightened neuropsychiatric burden relevant to brain aging.

Methods: A two-sample Mendelian randomization (MR) design using IEU OpenGWAS and FinnGen R12 was employed to evaluate causal associations between AD-related exposures and tinnitus. Clinical validation was conducted in 262 patients with chronic idiopathic tinnitus (compensated, n=150; decompensated, n=112, defined by Tinnitus Handicap Inventory [THI] ≥38), focusing on sleep quality (PSQI) and anxiety/depression (HADS). Logistic regression identified independent risk factors for decompensation.

Results: MR revealed significant causal associations with tinnitus: poor overall health (OR=1.605), frequent fatigue (OR=1.929), high anxiety (OR=2.818), and smoking history (OR=2.688). Clinically, decompensated patients exhibited significantly higher rates of sleep disorders (63.39% vs. 34.67%, P<0.001) and a higher proportion of disease duration ≥4 years (40.18% vs. 26.00%, P=0.043). Logistic regression identified Kidney Deficiency TCM syndrome (OR=13.428), HADS-A score (OR=1.174), PSQI score (OR=1.163), and VAS loudness (OR=3.293) as independent risk factors for decompensation. Notably, anxiety and sleep disturbances independently affected tinnitus severity without significant interaction (P=0.876), mirroring independent neuropsychiatric pathways implicated in AD prodrome.

Conclusion: Chronic tinnitus, particularly in its decompensated state, clusters with major AD-modifiable risk factors including anxiety, sleep disruption, fatigue, and smoking. These findings suggest that clinical screening for decompensated tinnitus may offer a peripheral window into central neuropsychiatric vulnerability, warranting longitudinal cognitive follow-up in this population.

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Keywords: Chronic Idiopathic Tinnitus, Clinical Features, Risk Factors

Introduction

Tinnitus, the perception of sound in the absence of an external source, affects approximately 14%–20% of adults, with 2% experiencing severe forms that markedly reduce quality of life [1]. It is frequently accompanied by depression, insomnia, concentration difficulties, and social impairment, and in severe cases, suicidal ideation [2]. While traditional research has focused on audiological mechanisms, emerging evidence positions hearing impairment as the foremost modifiable risk factor for Alzheimer's disease (AD), accounting for an estimated 7%–8% of global dementia cases according to the 2024 Lancet Commission on Dementia Prevention [3]. However, tinnitus, a common comorbidity of hearing loss, has been surprisingly overlooked in cognitive aging research [4-6].

Recent Mendelian Randomization (MR) studies have suggested causal links between insomnia, social stress, gut microbiota, hearing loss, depression, and tinnitus [7-11]. Cresswell et al. demonstrated that genetically instrumented hearing loss (OR=8.65), major depression (OR=1.26), and neuroticism (OR=1.48) predict current tinnitus. Clifford et al. identified genetic correlations between tinnitus and neuropsychiatric disorders including major depressive disorder. Nevertheless, the shared etiological architecture between tinnitus and AD-related neuropsychiatric states remains incompletely characterized.

Given that anxiety, sleep fragmentation, and chronic fatigue are not only distress amplifiers in tinnitus but also established drivers of neuroinflammation and glymphatic dysfunction in AD, we hypothesize that decompensated tinnitus may represent an accessible clinical marker of heightened brain vulnerability [12-14]. This study integrates two-sample MR to establish causality

with real-world clinical data to characterize the risk profile of tinnitus decompensation, aiming to identify potential early warning signs for cognitive decline.

Object and Method

Mendelian Randomization Analysis

A two-sample Mendelian randomization design was adopted, with genetic variation as an instrumental variable, to evaluate the causal relationship between each exposure factor and tinnitus to overcome the confounding bias of traditional observational studies [15]. Exposure data were obtained from the IEU OpenGWAS database (https://api.opengwas.io/) and outcome data were obtained from FinnGen R12 version (finngen_R12_H8_TINNITUS). Inclusion criteria: (1) Chain imbalance (r^2<0.001, window=10 000 kb) has been removed; (2) P<5×10^{-8} in inverse variance weighted (IVW); (3) The number of single nucleotide polymorphisms (SNPs) ≥3. Twenty-three exposure factors were preliminarily screened out (supplementary table 1). MR-Egger regression was used to detect pleiotropy at the level, and exposures with P<0.05 (ukb-b-6991, ukb-b-14203, ukb-b-6519) were eliminated [16-18]. The F statistic of each SNP was calculated, and the weak instrumental variables of F<10 were excluded, and 12 exposure factors were finally retained (Table 1). Sensitivity analysis was performed using the MR-PRESSO method, which corrected for outliers and retested for horizontal pleiotropy. All analyses were performed in R 4.4.3 software using the "TwoSampleMR" package [19,20].

Analysis of Clinical Characteristics of Chronic Idiopathic Tinnitus

Research Objects

The data of patients with chronic idiopathic tinnitus who attended the Department of Otolaryngology of the Affiliated Municipal Hospital of Traditional Chinese Medicine of Shanghai University of Traditional Chinese Medicine from March 2024 to February 2025 were retrospectively collected. This study was approved by the hospital ethics committee (2024SHL-KY-45-01) and has been registered in the China Clinical Trials Registry (ChiCTR2400083293). All patients signed the informed consent form.

Diagnostic Criteria

Western medicine diagnosis refers to the "European Multidisciplinary Tinnitus Guidelines" and "Clinical Application Guidelines for Tinnitus": patients consciously have unilateral or bilateral tinnitus, which may or may not be accompanied by hearing loss, hyperacusis, sleep disorders, irritability, anxiety, etc., and the course of the disease is ≥ 6 months; Audiological examination (pure tone audiometry, acoustic inactivity, otoacoustic emission, tinnitus frequency matching) and head CT/MRI rule out organic and space-occupying lesions [21-23].

Inclusion and Exclusion Criteria

Inclusion criteria:

- Meet the above diagnoses
- Age 18-80 years old, gender is not limited
- Have good communication skills and be able to complete the scale
- Signed informed consent.

Exclusion Criteria:

- Otitis media, otosclerosis
- cerumenium embolism and other external middle ear diseases
- Organic causes such as trauma, surgery, autoimmune diseases, acoustic neuromas, etc. Objective tinnitus caused by thyroid dysfunction, hypertension, anemia, etc.
- Recent use of ototoxic drugs
- Pregnancy or lactation.

Audiology Examination

The 0.25-8 kHz air conduction threshold was tested using the Danish Audio Traveller AA222 audiometer and Titan platform, and the acoustic conductivity and otoacoustic emission checks were performed at the same time. The average hearing threshold of 0.5, 1, 2, and 4 kHz was calculated according to the WHO hearing loss classification: <26 dB HL was normal, 26-40 dB HL was mild, 41-60 dB HL was moderate, 61-80 dB HL was severe, and ≥ 81 dB HL was very severe (the latter two were combined to be severe). Tinnitus frequencies are divided into low frequency (<1 kHz), medium frequency (1-3 kHz), and high frequency (≥4 kHz) [24].

Scale Evaluation

All patients fill out the following scales at the initial visit:

Tinnitus Disability Scale (THI): 25 items in total, with a total score of 0-100 points, and the higher the score, the more severe the disability. Compensation (<38 points) and loss of compensation (≥38 points) were divided by 38 points [25-27].

Tinnitus Rating Scale (TEQ) [28].

Pittsburgh Sleep Quality Index (PSQI): A total score of >5 suggests sleep disturbances [29].

Hospital Anxiety and Depression Scale (HADS): includes two subscales, anxiety (HADS-A) and depression (HADS-D), and each subscale is positive ≥8 points [30, 31].

Visual analogue score (VAS) for tinnitus loudness and annoyance: 0-10 points, with higher scores increasing.

Determination of TCM Syndrome Type

Referring to the "Otolaryngology of Traditional Chinese Medicine", patients were divided into liver qi stagnation, spleen and stomach weakness, cardiovascular blood deficiency, and kidney deficiency [32].

Statistical Methods

SPSS 28.0 software is used. Continuous variables that conform to normal distribution are expressed as mean ± standard deviation (X±σ), and non-conformity is expressed as median (interquartile range) M(IQR); Comparisons between groups were performed using t-test or Mann-Whitney U test. Categorical variables were expressed as examples (%), and the χ^2 test was used for comparison between groups. Univariate analysis was used to compare the differences in clinical characteristics between the compensated group and the decompensated group, and the variable of P<0.10 was included in the binary logistic regression (forward LR method) to analyze the risk factors of decompensation. Two-way analysis of variance was used to explore the interaction between sleep disorders and anxiety and depression. Inspection level α=0.05 (bilateral).

Results

Mendelian Randomization Analysis Results

IVW, MR-Egger, and MR-PRESSO screened layer by layer, and four exposure factors with significant causal associations with tinnitus were identified: overall health rating (UKB-A-251), frequency of fatigue/drowsiness in the past 2 weeks (UKB-B-929), frequency of nervousness/restlessness in the past 2 weeks (UKB-B-5664), and smoking history (UKB-B-20261). The OR values and sensitivity analysis results of each exposure are shown in Table 2, and the scatter plots are shown in Fig. 1-4.

Clinical Characteristics of Patients with Chronic Idiopathic Tinnitus

A total of 262 patients were included, including 150 (57.25%) in the compensated group and 112 (42.75%) in the decompensated group. There were no significant differences in age, gender, side, tinnitus status, chronic medical history, family history, pressure to stay up late, and the proportion of hearing loss between the two groups (P>0.05). The proportion of patients with a disease duration of ≥ 4 years in the decompensated group was significantly higher than that in the compensated group (P=0.043), and the proportion of sleep disorders was significantly higher than that in the compensated group (P<0.001) (Table 2).

Distribution of TCM syndrome types: 102 cases (38.93%) of liver qi stagnation, 77 cases (29.39%) of spleen and stomach weakness, 62 cases (23.66%) of cardiovascular insufficiency, and 21 cases (8.02%) of renal loss. The proportion of liver qi stagnation and renal loss type in the decompensated group was significantly higher than that in the compensated group, and the proportion of spleen and stomach weakness type was significantly lower than that in the compensated group (P<0.05) (Supplementary table 1). There were no significant differences in pure tone hearing threshold, tinnitus loudness and tinnitus frequency between the two groups (P>0.05) (Supplementary table 2). The total scores of THI, TEQ, HADS, and the subscales, PSQI, VAS loudness, and VAS distress scores in the decompensated group were significantly higher than those in the compensated group (P<0.001) (Supplementary table 3).

Analysis of Risk Factors for Tinnitus Decompensation

Taking decompensation as the dependent variable (THI≥38 points=1, <38 points=0), the variables with P<0.10 (disease course, liver qi stagnation, spleen and stomach weakness, renal loss, HADS-A, HADS-D, PSQI, VAS LOUDNESS, VAS distress) were used as independent variables, and binary logistic regression (forward LR method) was performed. The variables that finally entered the model were renal loss type, HADS-A, PSQI, and VAS loudness (Table 3). Among them, renal loss type (OR=13.428, 95%CI: 1.880-95.928, P=0.010), HADS-A (OR=1.174, 95%CI: 1.053-1.309, P=0.004), PSQI (OR=1.163, 95%CI: 1.022-1.324, P=0.022), and VAS loudness (OR=3.293, 95%CI: 2.353-4.609, P<0.001) were all independent risk factors for decompensation.

Interaction Between Sleep Disorders and Anxiety and Depression

Two-way analysis of variance was performed with THI score as the dependent variable, anxiety and depression (HADS-A or HADS-D≥8 points) and sleep disturbance (PSQI>5 points) as fixed factors. The results showed that the main effects of anxiety and depression (F=13.066, P<0.001) and sleep disturbance (F=25.995, P<0.001) were significant, but there was no significant interaction between the two (F=0.024, P=0.876) (Table 4).

Discussion

This study uniquely integrates Mendelian randomization with clinical retrospective analysis to explore risk factors for chronic idiopathic tinnitus and their implications for brain health. The MR results demonstrate causal associations between poor overall health, recent fatigue, anxiety, and smoking history with tinnitus, partially confirming and extending previous observational and MR studies. Strikingly, these four factors are not merely tinnitus correlates; they are central pillars in the lifestyle intervention portfolio for Alzheimer's disease (AD) prevention. The 2024 Lancet Commission on Dementia Prevention identified hearing loss as the single largest modifiable risk factor, accounting for an estimated 7%–8% of global dementia cases, while smoking, depression/anxiety, and physical inactivity (closely linked to fatigue) are all established modifiable targets. Our MR findings suggest that tinnitus shares a common etiological architecture with these AD-related risk factors, positioning it as a potential sentinel phenotype for accelerated brain aging.

Clinical data analysis showed that 42.75% of patients with chronic idiopathic tinnitus were decompensated, and their anxiety, depression, sleep disorders, and tinnitus-related distress were significantly heavier than those who were compensated, which was consistent with previous reports [33]. Logistic regression suggested that renal deficiency TCM syndrome, anxiety level (HADS-A), sleep quality (PSQI) and subjective tinnitus loudness (VAS loudness) were independent risk factors for decompensation. The risk of decompensation in patients with renal deficiency type is 13.4 times higher than that of non-renal deficiency type, which may be consistent with the traditional Chinese medicine theory that "long-term illness must be deficient": the kidney opens in the ear, and kidney deficiency leads to the loss of nutrition in the ear orifice, and the tinnitus is lingering and difficult to heal, and it is more likely to develop into a decompensated state. Intriguingly, the TCM "Kidney Deficiency" phenotype—which conferred the highest decompensation risk—may correspond to a traditional nosological description of neuroendocrine-immune dysregulation, a state increasingly recognized in aging research as a contributor to allostatic load and neurodegenerative vulnerability. Although the kidney deficiency type accounts for only 8.02%, once it appears, its impact is significant [34-36].

Anxiety and sleep disorders play an important role in tinnitus decompensation. In this study, the risk of decompensation increased by 17.4% for every 1 point increase in HADS-A. For every 1 point increase in PSQI, the risk increases by 16.3%. Interaction analysis showed that there was no significant interaction between anxiety and sleep disorders on THI, suggesting that they may affect tinnitus severity independently rather than synergistically enhance it. This independence is particularly noteworthy from an AD perspective. Sleep fragmentation and anxiety have been implicated in glymphatic dysfunction and impaired amyloid-β clearance, as well as HPA-axis hyperactivation and neuroinflammation, respectively [37-40]. The absence of interaction (P=0.876) suggests these two pathways may converge on central auditory processing networks through distinct neurobiological mechanisms, yet both contribute to the vulnerability of the aging brain [41].

Subjective tinnitus loudness (VAS loudness) was the strongest predictor of decompensation (OR=3.293), while there was no difference in objective tinnitus loudness (dB HL) between the two groups, which once again confirmed that the subjective perception of tinnitus is not parallel to the objective test results [42,43]. The patient's level of concern, negative perceptions, and emotional responses to tinnitus may amplify their perceived loudness, which in turn affects the THI score. This dissociation has direct relevance to cognitive reserve and default mode network (DMN) function—two constructs central to AD research [44-46]. Aberrant salience network activity and DMN dysfunction are early features of AD, and the amplification of internal auditory signals in decompensated tinnitus may reflect similar network-level disruptions [47].

In this study, there were no significant differences in age, gender, and hearing level between the two groups, which contradicted some literature. This may be because these factors indirectly affect tinnitus through sleep and anxiety, and their direct effects are weakened when the latter are included in the regression model.

This finding is consistent with the "cascade hypothesis" of AD, in which hearing loss contributes to dementia through intermediary pathways including social isolation, depression, and cognitive load. The absence of difference in the frequency distribution of tinnitus further supports the dissociation between the objective characteristics of tinnitus and the patient's degree of distress [48-50].

The advantage of this study is that it combines MR with clinical data, which not only provides causal evidence, but also verifies its performance in real-world populations. Limitations include:

- cross-sectional design cannot establish causal relationships;
- single-center sample, with limited extrapolation;
- some data are missing, resulting in a decrease in sample size;
- the interaction between sleep and anxiety needs to be verified by a larger sample and longitudinal study;
- no cognitive assessment (e.g., MMSE or MoCA) was administered, which precludes direct correlation between decompensated tinnitus and objective cognitive performance, this should be addressed in future prospective cohort studies.

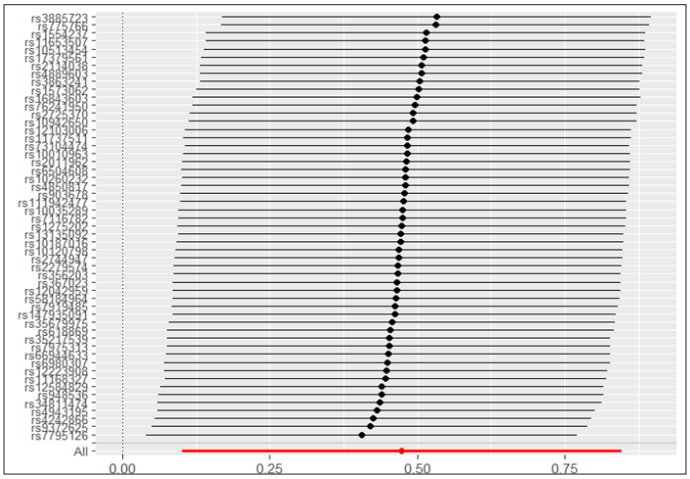

Figure 1: Effect of each SNP filtered in the ukb-a-251 database on tinnitus

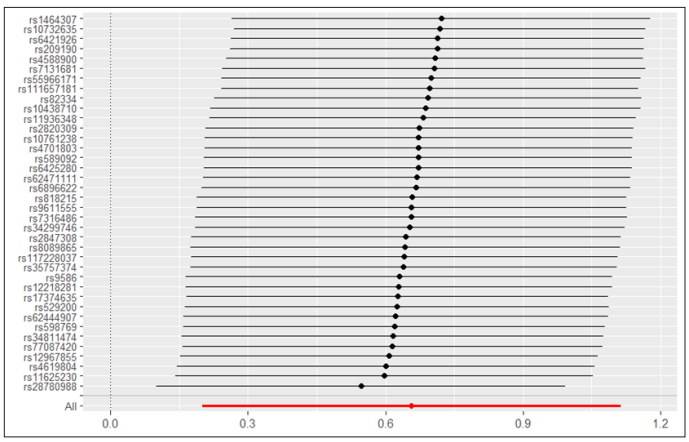

Figure 2: Effect of each SNP filtered in the UKB-B-929 database on tinnitus

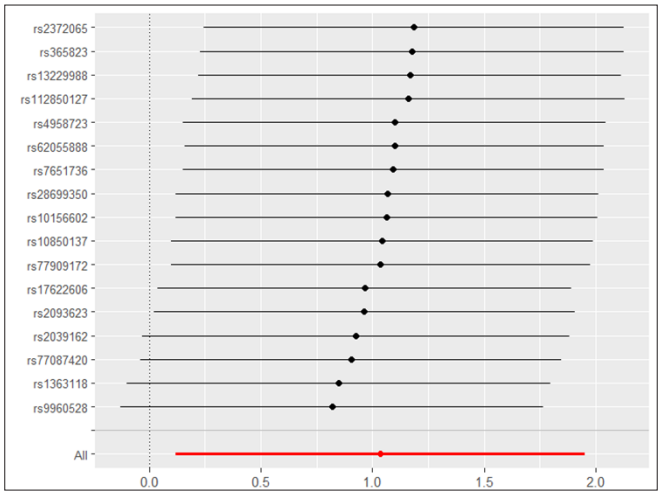

Figure 3: Effects of each SNP filtered in the UKB-B-5664 database on tinnitus

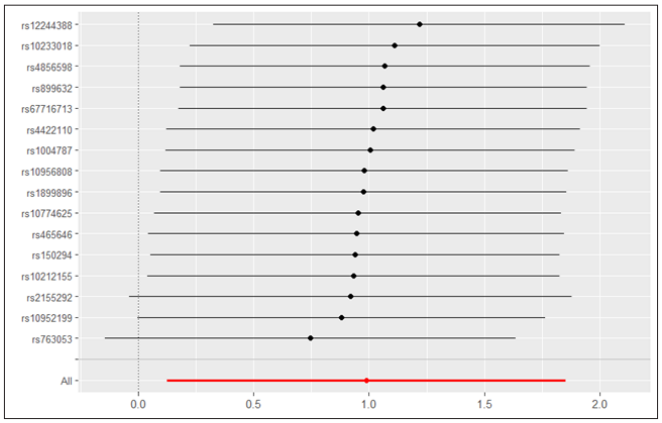

Figure 4: Effects of each SNP filtered in the ukb-b-20261 database on tinnitus

Table 1: Names of Tinnitus Risk Factors Screened Based on Mendelian Randomization

Database ID	Phenotypic name
ukb-a-251	Overall health rating
ukb-a-257	Hearing difficulty/problems: Yes
ukb-a-77	Non-cancer illness code self-reported: hypothyroidism/myxoedema
ukb-b-15782	Log MAR, final (right)
ukb-b-18275	Hearing difficulty/problems with background noise
ukb-b-19732	Non-cancer illness code, self-reported: hypothyroidism/myxoedema
ukb-b-20261	Ever smoked
ukb-b-4630	Neuroticism score
ukb-b-5664	Frequency of tenseness / restlessness in last 2 weeks
ukb-b-6306	Overall health rating
ukb-b-6541	Main speciality of consultant (recoded): General surgery
ukb-b-929	Frequency of tiredness / lethargy in last 2 weeks

Conclusion

Among patients with chronic idiopathic tinnitus, those with a disease course of ≥ 4 years, liver qi stagnation type, and renal loss type are more likely to enter a state of decompensation. Anxiety, sleep quality, subjective tinnitus loudness, and renal deficiency syndrome type are independent risk factors for decompensation. The effects of anxiety and sleep disturbances on tinnitus severity are independent of each other and do not interact significantly. Clinical evaluation should pay attention to the patient's subjective feelings and psychological state, and early intervention for risk factors may delay or prevent tinnitus decompensation.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the Municipal Hospital of Traditional Chinese Medicine Affiliated to Shanghai University of Traditional Chinese Medicine (approval No. 2024SHL-KY-45-01) and was registered in the China Clinical Trials Registry (registration No. ChiCTR2400083293, date of registration: 2024-03-01). All clinical data were collected retrospectively from patients with chronic idiopathic tinnitus who attended the Department of Otolaryngology between March 2024 and February 2025. All patients provided written informed consent for the use of their medical records and scale data for research purposes. The Mendelian randomization analysis used only publicly available summary-level data from the IEU OpenGWAS database and FinnGen R12, which have obtained relevant ethical approvals and participant consents; no additional ethical approval was required for this part.

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Conflicts of interest

The authors declare that they have no competing interests.

Authors' Contributions

CZ and YG conceived and designed the study. CZ, LHW, HPZ, LJ, and XHL collected and analysed the clinical data. CZ performed the Mendelian randomization analysis. CZ and YG drafted the manuscript. XLZ and YG supervised the study and revised the manuscript critically for important intellectual content. All authors read and approved the final manuscript.

Consent for Publication

Not applicable. This manuscript does not contain any individual person's data in any form (e.g., individual details, images, or videos). All data are presented as aggregated or anonymized results.

Availability of Data and Materials

The datasets generated and/or analysed during the current clinical retrospective study are not publicly available due to patient privacy protection but are available from the corresponding author (Yu Guo and Xiangli Zeng) on reasonable request. The exposure GWAS summary data used in the Mendelian randomization analysis are publicly available from the IEU OpenGWAS database (https://api.opengwas.io/). The outcome data for tinnitus are available from the FinnGen consortium R12 release (https://www.finngen.fi/en/access_results). The R code used for the Mendelian randomization analysis is available from the corresponding author upon reasonable request.

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Table 2: Phenotypic Rescreening of Tinnitus Risk Factors based on Mendelian Randomization

Exposure factor sample database id	Exposure factors	Terminal factors	Number of SNPs	Inspection method	OR	OR(95%CI)	P	MR heterogeneity(dat) Q pval	MR_ pleiotropy_ test(dat) pval	MR-PRESSO P-value
ukb-a-251	Overall health rating	Tinnitus	53	Inverse variance weighted	1.605094	1.1055062-2.330450	0.01287406	0.3407136	0.5560519	0.3497
ukb-a-251	Overall health rating	Tinnitus	53	MR Egger	3.155808	0.3269394-30.461679	0.32515016	0.3182055		
ukb-a-251	Overall health rating	Tinnitus	53	Weighted median	1.493546	0.8787143-2.538572	0.13500120	-		
ukb-b-929	Frequency of tiredness / lethargy in last 2 weeks	Tinnitus	38	Inverse variance weighted	1.929077	1.2224377-3.044195	0.004758833	0.3148362	0.2680294	0.3204
ukb-b-929	Frequency of tiredness / lethargy in last 2 weeks	Tinnitus	38	MR Egger	6.624557	0.7362481-59.605938	0.100282765	0.3276134		
ukb-b-929	Frequency of tiredness / lethargy in last 2 weeks	Tinnitus	38	Weighted median	1.911233	0.9819252-3.720051	0.048078342	-		

ukb-b-5664	Frequency of tenseness / restlessness in last 2 weeks	Tinnitus	17	Inverse variance weighted	2.818066	1.1272680-7.044907	0.02667348	0.5677708	0.8321081	0.5779
ukb-b-5664	Frequency of tenseness / restlessness in last 2 weeks	Tinnitus	17	MR Egger	2.061105	0.1040513-40.827484	0.64182714	0.4977310		
ukb-b-5664	Frequency of tenseness / restlessness in last 2 weeks	Tinnitus	17	Weighted median	1.798594	0.5084583-6.362254	0.38309151	-		
ukb-b-20261	outcome Ever smoked	Tinnitus	16	Inverse variance weighted	2.688138	1.1326895-6.379583	0.02492502	0.5706780	0.7610737	0.5886
ukb-b-20261	outcome Ever smoked	Tinnitus	16	MR Egger	4.679743	0.1266735-172.885309	0.41609490	0.5019891		
ukb-b-20261	outcome Ever smoked	Tinnitus	16	Weighted median	3.547443	1.0416292-12.081414	0.04284333	0.5677708		

Table 3: Binary Logistic Regression Analysis of Tinnitus Decompensation Factors

Element	B	SE	WALD	Degree of freedom	P	OR	95%Cl
Deficiency of the kidney essence	2.597	1.003	6.703	1	0.010	13.428	1.880-95.928
HADS-A score	0.160	0.056	8.343	1	0.004	1.174	1.053-1.309
PSQI score	0.151	0.066	5.266	1	0.022	1.163	1.022-1.324
VAS Tinnitus Loudness Score	1.192	0.172	48.269	1	<0.001	3.293	2.353-4.609

Table 4: Interaction Between Sleep Problems and Anxiety in Chronic Idiopathic Tinnitus

	Class III sum of squares	Degree of freedom	Mean square	F	P
Adjusted model	26162.956a	3	8720.985	27.485	<0.001
Intercept	168536.396	1	168536.396	531.150	<0.001
Anxiety and depression	4145.750	1	4145.750	13.066	<0.001
Sleep disorders	8248.282	1	8248.282	25.995	<0.001
Anxiety depression * sleep disorders	7.713	1	7.713	0.024	0.876
Error	81864.662	258	317.305		
Total	448300.000	262			
Total amount after correction	108027.618	261			

Supplementary Table 1: Clinical Characteristics of Patients with Chronic Idiopathic Tinnitus Example/M(IQR)

Grouping		Compensatory tinnitus (150 cases)	Decompensated tinnitus (112 cases)	Z	P
Age (in years)		44.00 (18.00)	45.00(19.75)	-0.113	0.910
Gender	Male	83(55.33%)	50(44.64%)		
	Female	67(44.67%)	62(55.36%)	2.932	0.087
Side farewell	Unilateral	57(38.00%)	41(36.61%)		
	Bilateral	93(62.00%)	71(63.39%)	0.053	0.818
State	Sustained	117(78.00%)	96(85.71%)		
	Intermittent	33(22.00%)	16(14.29%)	2.510	0.113
Course of the disease	6-12 months	50(33.33%)	27(24.11%)		
	12months-4 years	61(40.67%)	40(35.71%)	6.286	0.043
	More than 4	39(26.00%)	45(40.18%)		
	Yes	56(37.33%)	46(41.07%)	0.377	0.539
	No	94(62.67%)	66(58.93%)		
	Yes	21(14.00%)	14(12.50%)		
	No	129(86.00%)	98(87.50%)	0.125	0.724
	Yes	52(34.67%)	71(63.39%)	21.245	<0.001
	No	98(65.33%)	41(36.61%)		
	Yes	85(56.67%)	66(58.93%)	0.134	0.714
	No	65(43.33%)	46(41.07%)		
	Yes	96(64.00%)	80(71.43%)	1.605	0.205
	No	54(36.00%)	32(28.57%)		
	Yes	49(32.67%)	53(47.32%)	5.792	0.016
	No	101(67.33%)	59(52.68%)		
	Yes	61(40.67%)	16(14.29%)	21.504	<0.001
	No	89(59.33%)	96(85.71%)		
	Yes	38(25.33%)	24(21.43%)	0.541	0.462
	No	112(74.67%)	88(78.57%)		
	Yes	2(1.33%)	19(16.96%)	21.249	<0.001
	No	148(98.67%)	93(83.04%)		

Supplementary Table 2: Tinnitus and Hearing Conditions of Patients with Compensated and Decompensated Tinnitus M(IQR)

Grouping	Side farewell	Compensatory tinnitus (150 cases)	Decompensated tinnitus (112 cases)	Z	P
Pure tone audiometry (dB HL)	Left side	21.20(17.06)	22.50(19.00)	-0.756	0.450
	Right side	18.80(14.02)	20.00(15.00)	-1.040	0.298
Tinnitus loudness (dB HL)	Left side	40.00(36.00)	40.00(42.75)	-0.185	0.853
	Right side	40.00(36.00)	40.00(40.75)	-0.865	0.387
Tinnitus frequency (kHz)	Left side	8.00(6.00)	4.00(7.00)	-1.103	0.270
	Right side	6.00(7.00)	6.00(7.00)	-0.008	0.994

Supplementary Table 3: Psychoacoustic scale of tinnitus in patients with compensated and decompensated tinnitus M(IQR)

Grouping	Compensatory tinnitus (150 cases)	Decompensated tinnitus (112 cases)	Z	P
THI	24.00(16.00)	50.00(18.00)	-13.853	<0.001
TEQ	10.00(4.00)	13.00(5.00)	-7.898	<0.001
HADS	6.00(10.25)	15.00(10.00)	-7.185	<0.001
HADS-A	3.00(6.00)	8.00(5.75)	-7.516	<0.001
HADS-D	3.00(5.25)	7.00(6.00)	-5.759	<0.001
PSQI	6.00(4.00)	9.75(5.00)	-7.705	<0.001
VAS loudness	4.00(1.25)	6.00(2.00)	-11.255	<0.001
VAS frustrations	3.00(1.00)	6.00(3.00)	-10.624	<0.001

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