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Effects of otolaryngological diseases on sleep quality, anxiety, and depression: a multicenter observational study

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Abstract

Background The impact of otolaryngological diseases on sleep quality, anxiety, and depression has garnered significant attention. However, research has primarily focused on unveiling the effects of only one or two specific diseases, without analyzing the impact of multiple concurrent diseases. Furthermore, investigation into the interaction mechanisms among these factors has been lacking.

Objectives This study reveals the effects of different otolaryngological diseases on sleep quality, anxiety, and depression, and investigates their interaction mechanisms.

Methods In total, 2,080 patients with otolaryngological diseases were recruited from six centers in mainland China. Data on sociodemographics, history of smoking and alcohol consumption, diagnosis, anxiety, depression, and sleep quality were collected through hospital information system queries and questionnaires. We uncovered the psychological status and sleep quality of otolaryngology outpatients with different diseases and revealed the interaction mechanisms between these diseases and anxiety, depression, and sleep quality. Multivariable polynomial linear regression models explored the impact of different otolaryngological diseases on anxiety, depression and sleep quality, and mediation analysis explored the interaction mechanisms.

Results Chronic laryngitis, eustachian tube disorders, laryngeal swelling, laryngopharyngeal reflux, neck lymphatic inflammation, snoring, sudden deafness, tinnitus, nasopharyngeal lesions, and trauma had a significant impact on Pittsburgh Sleep Quality Index scores. Chronic tonsillitis, chronic laryngitis, and laryngopharyngeal reflux had a significant impact on Zung Self-Rating Depression Scale scores. Patients with giddiness ($P=0.006$) and tinnitus ($P=0.006$) tended to have higher Zung Self-Rating Anxiety Scale scores. Anxiety mediated the effect of tinnitus on sleep quality (70.41%; 95% confidence interval [CI]: 40.07, 76.00), and depression also had a mediation effect (13.24%;

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95% CI: 4.46, 28.58). Other diseases also exhibited mediating effects and interactions with anxiety, depression, and sleep quality.

Conclusions Sleep quality significantly mediates the relationships of specific otolaryngological diseases with anxiety and depression. Similarly, anxiety and depression play important mediating roles in the relationships of different diseases with sleep quality. By revealing the interactive effects of different otolaryngological diseases on anxiety, depression, and sleep quality, this study could aid early interventions aiming to reduce anxiety and depression and improve patients' sleep quality and quality of life.

Keywords Otolaryngological diseases, Anxiety, Depression, Sleep quality

Panel: research in context

Evidence before this study

We searched PubMed, Embase, Web of Science, Scopus and Google Scholar for studies in any language published up to Dec 12, 2024 with the terms “Otolaryngological diseases”, “Anxiety”, “Depression”, “Sleep quality”, “Vocal leukoplakia”, “Vocal cord polyp”, “Trauma”, “Tonsil stones”, “Tinnitus”, “The pharyngeal mass”, “Sudden deafness”, “Stun”, “Snoring”, “Pharyngeal ulcer”, “Pharyngeal paraesthesia”, “Otitis media”, “Otitis externa”, “Neck lymphatic inflammation”, “Nasopharyngeal lesion”, “Nasal bone fracture”, “Mycosis of the ear canal”, “Laryngopharyngeal reflux”, “Laryngeal swelling”, “Hoarseness”, “Hearing loss”, “Giddy”, “General examination”, “Foreign body in pharynx”, “Auditory meatus eczema”, “Eustachian tube disorders”, “Epistaxis”, “Earwax impaction”, “Ear mass”, “Dry rhinitis”, “Cough”, “Congenital preauricular fistula”, “Chronic tonsillitis”, “Chronic sinusitis”, “Chronic rhinitis”, “Chronic pharyngitis”, “Chronic nasopharyngitis”, “Chronic laryngitis”, “Auricular abscess”, “Allergic rhinitis”, “Allergic pharyngitis”, “Adenoid hypertrophy”, “Acute tonsillitis”, “Acute sinusitis”, “Acute rhinitis”, “Acute pharyngitis”, “Acute otitis media”, and “Acute laryngitis”. Several studies have investigated the associations between anxiety, depression, and sleep quality in patients with otolaryngological diseases. For example, Alt et al. [1]. examined sleep quality in patients with chronic rhinosinusitis before and after functional endoscopic sinus surgery. Hou et al. [2]. employed a retrospective cohort study to explore the association between anxiety disorder and tinnitus. Wang et al. [3]. investigated the characteristics of sleep disorders and anxiety in tinnitus patients, though very few studies have simultaneously explored psychological health and sleep quality across various ear, nose, and throat diseases. Brandsted et al. [4]. estimated that the prevalence of depression in patients with chronic rhinosinusitis is in the range of 20–25%. Kratzsch et al. reported that, of patients with decompensated tinnitus (severe tinnitus distress), 40–60% suffer from major depression, 15–60% from anxiety disorders, and 20–50% from somatoform disorders. Only 7–11% of these patients do not suffer from any psychiatric disorder [5]. It has been found that certain other ear, nose, and throat

disorders may also lead to a certain degree of anxiety and depression [6, 7]. However, the existing literature only reveals the impact of one or two specific types of diseases on anxiety, depression, and sleep quality [1–3, 8]. Moreover, research into the interaction mechanisms between these diseases and their effects on anxiety, depression, and sleep quality remains limited.

Added value of this study

We conducted a multicenter observational study in otolaryngology outpatient departments, uncovering the psychological status and sleep quality of otolaryngology outpatients with different diseases. The study provides insights into the variations in anxiety, depression, and sleep quality among otolaryngology outpatients with different diseases. Additionally, it reveals interactive mechanisms and the direct and indirect effects of the diseases on anxiety, depression, and sleep quality.

Implications of all the available evidence

To our knowledge, this study is the first to explore the sleep quality, anxiety, and depression status of otolaryngology outpatients with different diseases, while also revealing the interrelationships of these variables. We found that sleep quality significantly mediates the relationships of specific otolaryngological diseases with anxiety and depression. Similarly, anxiety and depression play important mediating roles in the relationships of different diseases with sleep quality. By elucidating the interactive effects of various otolaryngological diseases on anxiety, depression, and sleep quality, this study can guide early interventions to reduce anxiety and depression, enhance sleep quality, and improve the overall quality of life for patients. These insights can facilitate more personalized management and care for otolaryngology outpatients, ultimately reducing the incidence of depression and anxiety, and improving sleep quality and quality of life.

Background

Sleep is an essential physiological need of human beings that can relieve fatigue and restore physical strength. Many diseases of the ear, nose, and throat, such as snoring, tinnitus, and allergic rhinitis, have been extensively

studied and confirmed by numerous researchers to have a profound impact on the quality of sleep of patients [9–11]. Poor sleep quality often leads to fatigue, poor concentration, poor reflexes, and impaired judgment, which increases the risk of traffic accidents, industrial accidents, medical errors, and decreased productivity [12]. Additionally, studies have shown that poor sleep quality is often accompanied by feelings of anxiety and depression in patients. Complaints of poor sleep are reported by up to 90% of people with diagnosed depression [13] and up to 70% of people with anxiety [14].

The global incidence of anxiety and depression is continuously increasing, making it a significant public health concern worldwide [15]. According to data from the World Health Organization, more than 200 million people worldwide suffer from depression, and over 370 million people suffer from anxiety disorders [16]. The symptoms of anxiety and depression include persistent psychological distress, appetite changes, fatigue, and lack of concentration, severely impacting the quality of life of those affected. Depression is also closely associated with an increased risk of suicide, with approximately 750,000 individuals worldwide losing their lives due to suicide each year, a significant proportion of whom have depression. Many diseases related to the ear, nose, and throat not only increase the likelihood of anxiety and depression among patients by affecting sleep quality but also directly exacerbate depression and anxiety. Brandsted et al. estimated that the prevalence of depression in patients with chronic rhinosinusitis is in the range of 20–25% [4]. Kratzsch et al. reported that, of patients with decompensated tinnitus (severe tinnitus distress), 40–60% suffer from major depression, 15–60% from anxiety disorders, and 20–50% from somatoform disorders [5]. Only 7–11% of these patients do not suffer from any psychiatric disorder [5]. It has been found that certain other ear, nose, and throat disorders may also lead to a certain degree of anxiety and depression [6, 7]. Therefore, anxiety, depression, and sleep quality in patients with different diseases of the ear, nose, and throat have garnered significant attention from researchers and society.

However, the existing literature only reveals the impact of one or two specific types of diseases on anxiety, depression, and sleep quality [1–3, 8], with very few studies simultaneously exploring psychological health and sleep quality across different ear, nose, and throat diseases. Moreover, there has been limited research on the interaction mechanisms between these diseases and their impact on anxiety, depression, and sleep quality. Therefore, we put forward the research question of this study: which diseases of otolaryngology have the greatest impact on patients' anxiety, depression and sleep quality, and whether there are interaction mechanisms between these diseases and anxiety, depression and sleep quality.

We conducted a multicenter observational study in otolaryngology outpatient departments, uncovering the psychological status and sleep quality of otolaryngology outpatients with different diseases. The study provides insights into the variations in anxiety, depression, and sleep quality among otolaryngology outpatients with different diseases. Additionally, it reveals interactive mechanisms and the direct and indirect effects of the diseases on anxiety, depression, and sleep quality.

Methods

Study design

This multicenter observational study collected data on the sleep quality, anxiety, and depression status of patients with different otolaryngological disorders. Baseline recruitment was conducted from May 2022 to May 2023, and patients were followed regarding pregnancy outcomes. Patients visiting the otolaryngology outpatient departments of six hospital campuses across three districts of Zhejiang Province were recruited when they met the following inclusion criteria: any disease of the ear, nose, or throat; and resident of Hangzhou, Shaoxing, or Jiaxing during the past half year. We excluded individuals with intellectual impairments unable to comprehend the questionnaire and provide accurate answers, and individuals who could not be followed up with respect to their clinical examination results. The patients completed the survey questionnaires while waiting in line for their appointments. The study was approved by the institutional review boards of the First Affiliated Hospital of Zhejiang University School of Medicine (IIT20230317B), Zhejiang Xin'an International Hospital (XA-K-2023-008), and Shaoxing Second Hospital (SxSH-ECAL-2023-033). All patients gave written informed consent at the time of enrollment.

Covariates

Data on covariates, including gender, age, education level, employment status, marital status, region of residence, smoking, and alcohol consumption, were collected when patients presented to the otorhinolaryngology outpatient clinic seeking consultations. Information on disease diagnoses was obtained through the hospitals' medical electronic information systems, which automatically record information during each visit.

Subjective sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI) [17], which includes 18 items representing seven components. Each item is rated on a scale ranging from 0 to 3, and the sum of the component scores yields the total PSQI score. Higher scores indicate poorer sleep quality, with total scores ranging from 0 to 21. The total score ranged from 0 to 21, with a score of >7 indicating poor sleep quality (sleep disturbance) in this study, with 98% high sensitivity and 90%

specificity ($\kappa = 0.89$, $p < 0.01$), suitable for Chinese [18].

Depression status was assessed using the Zung Self-Rating Depression Scale (SDS) [19], which comprises 20 questions, suitable for Chinese [20]. Participants provided their responses via a four-point scale ranging from 1 (*ever or very rarely*) to 4 (*most or all of the time*). The raw score was obtained by summing all the responses, and the standard score was calculated by multiplying the raw score by 1.25. A diagnosis of depression was made for participants with an index score ≥ 50 .

The assessment of anxiety status was conducted using the Zung Self-Rating Anxiety Scale (SAS) [21], which comprises 20 questions, suitable for Chinese [20]. Participants rated their responses on a four-point scale ranging from 1 (*ever or very rarely*) to 4 (*most or all of the time*). By summing all the responses, the raw score was obtained, which was then multiplied by 1.25 to calculate the standard score. Participants with an index score of ≥ 50 were identified as having anxiety.

Mediation analysis

A multiple mediation model was used to estimate the direct and indirect effects of different otolaryngological diseases on sleep quality metrics, anxiety, and depression. Linear regression with the product of coefficients method was used to estimate the effect of the exposure on the mediators (ai ; $i = 1, 2$), the effect of the mediators on the outcome (bi ; $i = 1, 2$), and the direct effect of the exposure on the outcome after adjusting for the mediators (c'). The average causal mediation effect for each mediator was then calculated as $\gamma_i = ai \times bi$; $i = 1, 2$ and the proportion mediated by the i th mediator was given by $100 \times \gamma_i / (c' + \gamma_1 + \gamma_2)$. Using the R package lavaan (version 0.6–12), confidence intervals (CIs) for the average causal mediation effects were computed using a bootstrap approach (1,000 resamples) to relax the assumption of normally distributed residuals.

Statistical analysis

Mean values with corresponding 95% CIs were used to represent continuous variables, whereas median values with interquartile ranges were used for ordinal variables. Multivariable linear regression models were used to estimate the regression coefficients, and their 95% CIs, in the analysis of the relationships of SAS, SDS and PSQI scores with different diseases. The 95% CIs for regression coefficients were obtained using a residual bootstrap approach with 1,000 resamples. Proportions of categorical variables were compared using χ^2 tests. Pairwise comparisons were conducted using the Welch t-test. To control the false discovery rate, a Bayesian procedure was applied to adjust for multiple comparisons. All statistical analyses were conducted in R (version 4.2.0; R Development

Core Team, Vienna, Austria), with $p < 0.05$ considered significant.

Results

Participant recruitment

A total of 2,080 participants were enrolled from otolaryngology outpatient departments, of whom 1,979 (95.14%) ultimately took part (1,168 [59.02%] participants from four campus locations at the First Affiliated Hospital of Zhejiang University School of Medicine, 379 [19.15%] participants from Zhejiang Xin'an International Hospital, and 432 [21.83%] participants from Shaoxing Second Hospital). In total, 1,857 of 1,979 (93.84%) participants who submitted complete questionnaires, and for whom complete clinical information was available, were included in the final analysis (Figure S1).

Basic characteristics

Among the 1,857 patients included in the final analysis, 50.3% (934) were male, 68.7% ($n = 1,275$) were unemployed, 70% ($n = 1,300$) had a bachelor degree or above, 52.6% ($n = 977$) were married, 13.1% ($n = 243$) lived in the countryside, 78.7% ($n = 1,462$) had never smoked, and 63.0% ($n = 1,169$) had never drunk alcohol. The mean age at baseline was 32.88 years (standard deviation [SD]: 12.41 years) (Table 1). The results for each variable, grouped by disease category, are shown in Table S1.

Sleep quality, anxiety, and depression

In this study, the average global PSQI score was 6.06 (SD: 3.71). Of the otolaryngology outpatients who participated, 31.2% ($n = 580$) had poor sleep quality. The average SAS standard score was 34.09 (SD: 8.88), and 7.1% ($n = 132$) of patients met the diagnostic threshold for anxiety. The average SDS standard score was 34.82 (SD: 10.65), and 11.6% ($n = 215$) of patients met the diagnostic threshold for depression (Table 1). The results for each variable, grouped by disease category, are shown in Table S1.

A total of 48 different diseases were recorded among the otolaryngology outpatients, including 14 types of ear disorders, 6 types of throat disorders, 15 types of pharyngeal disorders, 1 type of neck disorder, 8 types of nasal disorders, and 4 diseases classified of "other" (including trauma and diseases diagnosed on the basis of general medical examinations). Allergic rhinitis was the most prevalent disease (173 patients), followed by tinnitus (158 patients) (Fig. 1). The average SAS, SDS, and PSQI scores were highest for patients with neck disorders (Figure S2). The five diseases associated with the highest SAS scores were giddiness, chronic tonsillitis, trauma, chronic laryngitis, and tinnitus. Patients with these diseases were more likely to have anxiety symptoms. The five diseases associated with the highest SDS scores were chronic tonsillitis,

Table 1 Demographic, anxiety, depression, and sleep quality data of the study participants

Overall	n
case	1857
Age (mean (SD))	32.88 (12.41)
Categories	
Ear disorders	803 (43.3%)
Nasal disorders	407 (21.9%)
Neck disorders	16 (0.9%)
Pharyngeal disorders	468 (25.2%)
Throat disorders	54 (2.9%)
Other	108 (5.8%)
Sex=Male	934 (50.3%)
Occupation=Unemployed	1275 (68.7%)
Education	
Senior high school and below	323 (17.4%)
Senior high school	234 (12.6%)
Bachelor's degree	1078 (58.1%)
Master degree or above	222 (12.0%)
Marriage	
Married	977 (52.6%)
Unmarried	830 (44.7%)
Other	50 (2.7%)
Region	
Countryside	243 (13.1%)
Provincial capital city	564 (30.4%)
Town/county	382 (20.6%)
Urban area	668 (36.0%)
Smoking	
Never	1462 (78.7%)
Now	237 (12.8%)
Previously	158 (8.5%)
Drinking	
Never	1169 (63.0%)
Now	393 (21.2%)
Previously	295 (15.9%)
SAS standard score (mean (SD))	34.09 (8.88)
SDS standard score (mean (SD))	34.82 (10.65)
PSQI (mean (SD))	6.06 (3.71)
poor sleep=YES	580 (31.2%)
anxiety=YES	132 (7.1%)
depression=YES	215 (11.6%)

chronic laryngitis, giddiness, trauma, and laryngopharyngeal reflux. Patients with these diseases were more likely to have depressive symptoms. The five diseases associated with the highest PSQI scores were trauma, laryngeal swelling, nasopharyngeal lesions, chronic laryngitis, and neck lymphatic inflammation. Patients with these diseases were more likely to have poor sleep quality. Patients undergoing general medical examinations had the lowest SAS, SDS, and PSQI scores (Figure S3).

Distribution of SAS, SDS, and PSQI scores among patients with different characteristics

There were significant differences in SAS scores among the different age groups ($P<0.001$). The highest SAS scores were found in the 18–45 years age group, followed by the >60 years and 45–60 years age groups. The lowest SAS scores were observed in the <18 years age group. The same pattern was observed for the SDS scores. The highest PSQI scores (indicating the poorest sleep quality) were in the 45–60 years age group. The group aged >60 years had the second-highest PSQI scores, whereas the sleep quality was best in the group aged <18 years (Fig. 2).

Men had lower SAS, SDS, and PSQI scores compared with women (Figure S4). There were no statistically significant differences in SDS or SAS scores according to smoking status, but patients who had smoked in the past had higher PSQI scores compared with those who had never smoked, suggesting that former smokers may have poorer sleep quality than non-smokers (Figure S5). Similar patterns were observed regarding the impact of alcohol consumption on the SDS, SAS, and PSQI scores (Figure S6). The distribution of the SAS, SDS, and PSQI scores according to region of residence, education level, and marital status is shown in Figures S7–S9.

Associations between sleep quality and different diseases

The relationships between sleep quality and different diseases were assessed. Without adjusting for the SAS and SDS scores, patients with chronic laryngitis, eustachian tube disorders, laryngeal swelling, laryngopharyngeal reflux, neck lymphatic inflammation, snoring, sudden deafness, tinnitus, and trauma tended to have higher PSQI scores, indicating poorer sleep quality (Fig. 3). After adjusting for the SAS and SDS scores, patients with eustachian tube disorders, laryngeal swelling, laryngopharyngeal reflux, neck lymphatic inflammation, snoring, sudden deafness, tinnitus, and nasopharyngeal lesions tended to have higher PSQI scores, suggesting a higher likelihood of poor sleep quality (Fig. 3).

Associations between depression and different diseases

The relationships between SDS scores and different diseases were assessed. Without adjusting for the SAS and PSQI scores, patients with chronic tonsillitis, chronic laryngitis, and laryngopharyngeal reflux tended to have higher SDS scores, indicating a higher likelihood of depression in these individuals (Figure S10). After adjusting for the SAS and PSQI scores, patients with chronic tonsillitis and chronic laryngitis tended to have higher SDS scores, indicating a higher likelihood of depression, whereas patients with giddiness tended to have lower SDS scores (Figure S10).

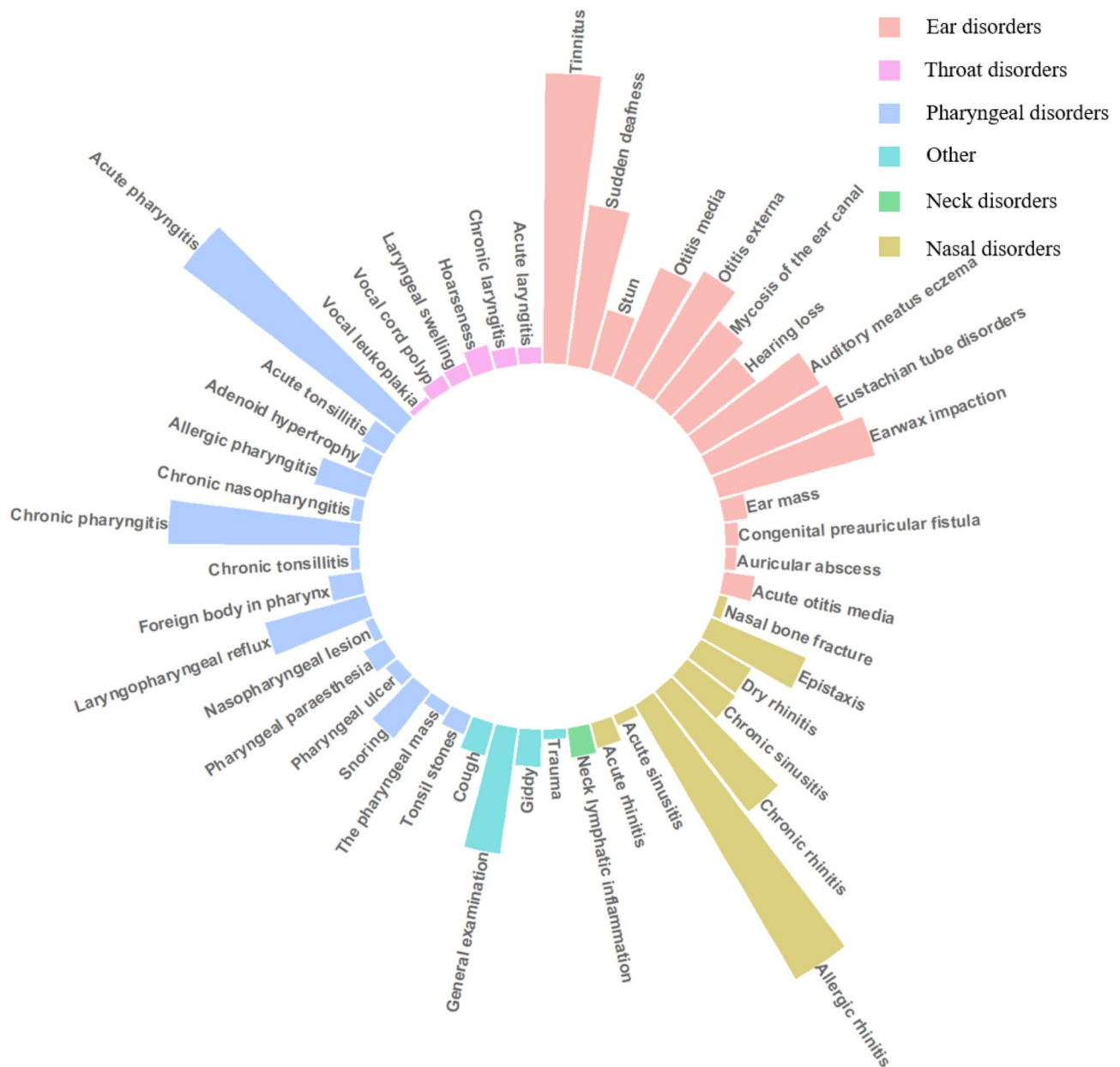


Fig. 1 The distribution of disease types in this study. The height of the bars represents the number of cases of the various diseases, while the color of the bars represents the category to which each disease belongs

Associations between anxiety and different diseases

The relationships between sleep quality and different diseases were assessed. Without adjusting for the SDS and PSQI scores, patients with giddiness and tinnitus tended to have higher SAS scores, indicating a higher likelihood of anxiety in these individuals (Figure S11). After adjusting for the SAS and PSQI scores, patients with giddiness tended to have higher SAS scores, indicating a higher likelihood of anxiety, whereas patients with acute tonsillitis tended to have lower SAS scores (Figure S11).

Mediation analysis

On examining the effects of different diseases on sleep quality, it was found that the outcomes were different between analyses adjusted and unadjusted for SAS and SDS scores. We speculate that there might be a mediating effect of SDS and SAS scores on the relationships between sleep quality and diseases. Therefore, mediation analyses were conducted separately for diseases that had a sufficient number of cases (> 50) and significantly affected sleep quality.

Mediation analysis was done to investigate the roles of anxiety and depression in mediating the relationship

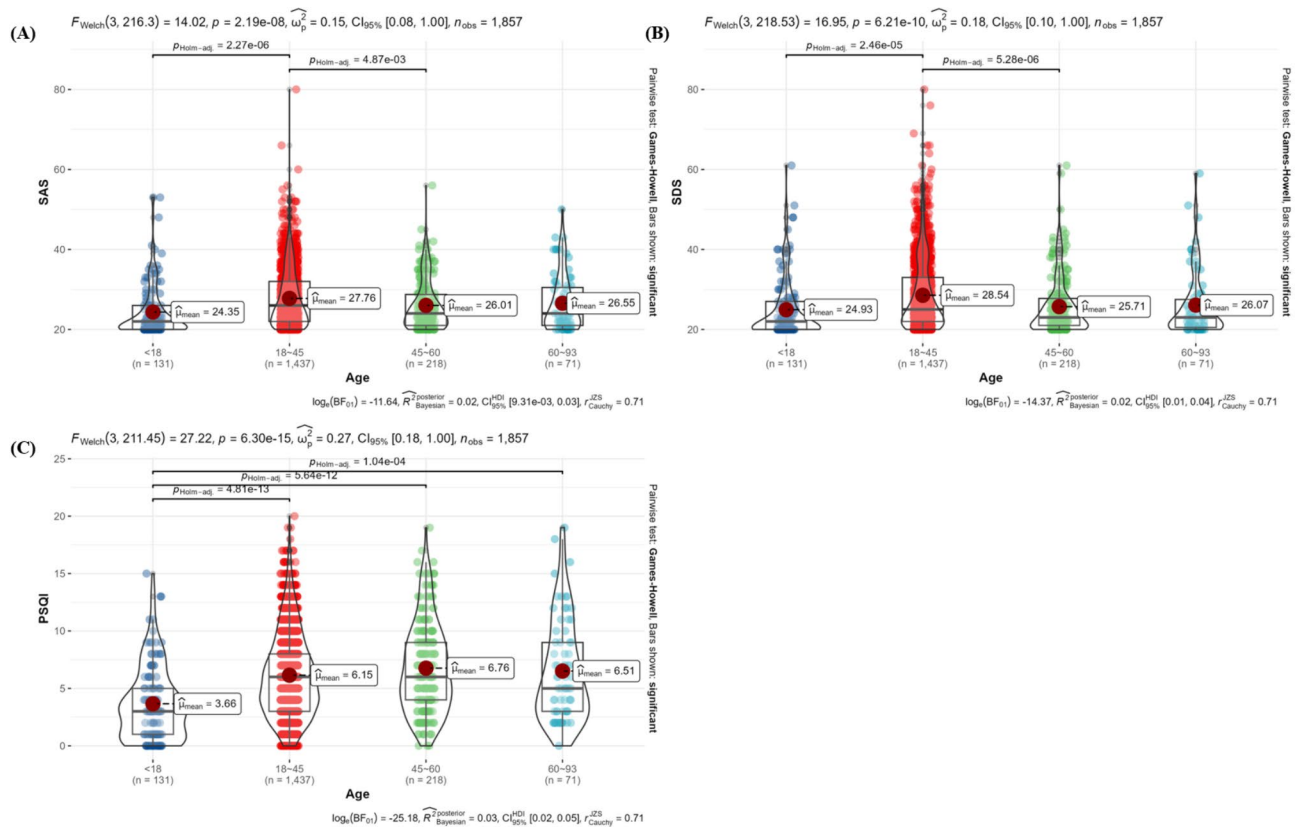


Fig. 2 The distribution of Zung Self-Rating Anxiety Scale (SAS), Zung Self-Rating Depression Scale (SDS), and Pittsburgh Sleep Quality Index (PSQI) scores by age group. **(A)** The distribution of SAS standard scores by age group. **(B)** The distribution of SDS standard scores by age group. **(C)** The distribution of PSQI scores by age group. The top row of each panel displays the following data: parameters, statistics, significance levels, effect sizes, confidence intervals, and number of observations. The bottom right corner of each panel shows the p-value-correction methods applied for pairwise comparisons. Significant differences in pairwise comparisons are indicated by continuous lines above the graph, with the corresponding p-values displayed

between sleep and tinnitus (Fig. 4A). Anxiety mediated the effect of tinnitus on sleep quality (70.41% [95% CI: 40.07, 76.00]), and depression also had a mediation effect (13.24% [95% CI: 4.46, 28.58]; Fig. 4B, Table S2). Similarly, anxiety mediated the effect of sudden deafness on sleep quality (59.49% [95% CI: 27.83, 71.97]), and depression also had a mediation effect (17.12% [95% CI: 3.05, 39.32]; Figure S12, Table S3). Anxiety and depression did not have a mediating effect on the relationship between eustachian tube disorders and sleep quality (Figure S13, Table S4).

We also evaluated the mediating effects of sleep quality and anxiety on the relationship of laryngopharyngeal reflux with depression: anxiety mediated the effect of laryngopharyngeal reflux on depression (80.26% [95% CI: 46.94, 83.52]), and depression had a similar mediation effect (4.09% [95% CI: 1.20, 9.09]; Figure S14, Table S5).

Finally, we evaluated the mediating effects of sleep quality and depression on the relationship of tinnitus with anxiety: depression mediated the effect of tinnitus on depression (59.71% [95% CI: 42.85, 68.45]), and sleep

quality also had a mediation effect (14.06% [95% CI: 7.78, 21.02]; Figure S15, Table S6).

Discussion

To our knowledge (Table S7), this study is the first to explore the sleep quality, anxiety, and depression status of otolaryngology outpatients with different diseases, while also revealing the interrelationships of these variables. In this study, the five diseases associated with the highest SAS scores were giddiness, chronic tonsillitis, trauma, chronic laryngitis, and tinnitus. Patients with these diseases were more likely to have anxiety symptoms. The five diseases associated with the highest SDS scores were chronic tonsillitis, chronic laryngitis, giddiness, trauma, and laryngopharyngeal reflux. Patients with these diseases were more likely to have depressive symptoms. The five diseases associated with the highest PSQI scores were trauma, laryngeal swelling, nasopharyngeal lesions, chronic laryngitis, and neck lymphatic inflammation. Patients with these diseases were more likely to have poor sleep quality. Among all patients, those who

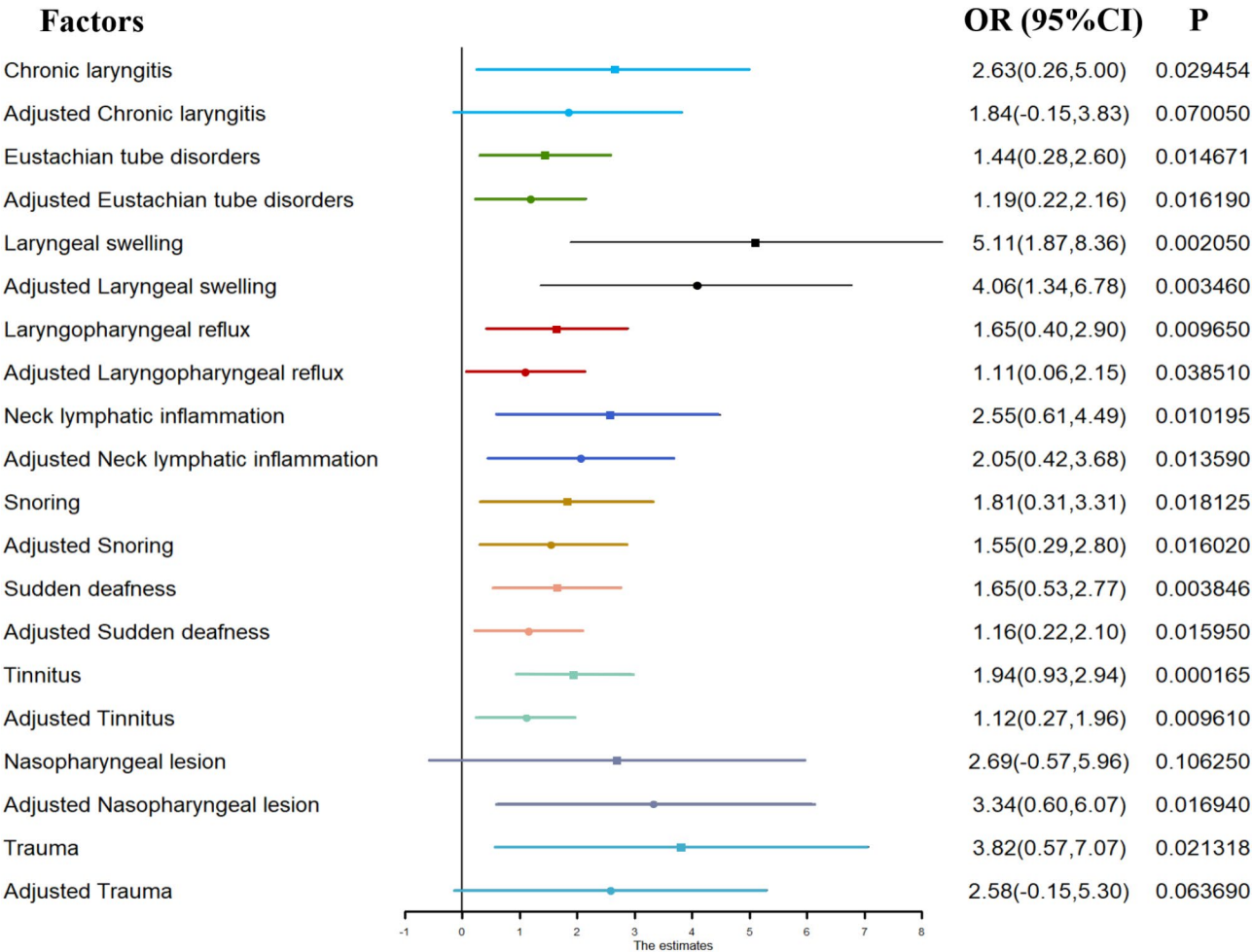


Fig. 3 Associations between different diseases and PSQI scores. Both unadjusted (squares) and multivariable (circles) polynomial linear regression coefficients are shown, alongside 95% confidence intervals and p-values. In both the unadjusted and multivariable polynomial linear regression models, associations were adjusted for age, sex, occupation, education, region of residence, smoking, drinking, and marital status. In the multivariable polynomial linear regression models, we additionally adjusted for the Zung Self-Rating Depression Scale scores and Zung Self-Rating Anxiety Scale scores. The reference standard for the diagnosis is general medical examination

underwent general medical examinations had the lowest SAS, SDS, and PSQI scores.

Tinnitus is a condition in which sound is perceived in the absence of a clear external auditory stimulus. In patients with severe tinnitus, a number of psychological disorders are often present, such as anxiety and sleep disorders [22]. In our study, the SAS scores of the tinnitus patients were in the top five among the various diseases of all otolaryngology outpatients. Jia et al. reported that transcranial direct current stimulation combined with tinnitus retraining therapy had obvious therapeutic effects on chronic tinnitus, markedly reducing its severity and improving patients' sleep quality and psychological status [23]. When in the sleep state, the activity state of the human brain changes from a passive response caused by external stimuli to a response dominated by internal initiative. Tinnitus is categorized into subjective tinnitus and objective tinnitus, with subjective tinnitus

accounting for the majority of tinnitus patients [24]. Like sleep, patients with subjective tinnitus exhibit self-perception of sound by the brain in the absence of an internal or external objective sound source. Therefore, patients with tinnitus, especially subjective tinnitus, may have some potential correlation with sleep states in terms of brain activity. According to the research surface, the effect of sleep on brain plasticity would lead to abnormal activity in neural pathways that would exacerbate tinnitus [25]. In this study, there was a strong correlation between tinnitus and patients' sleep quality. In addition, tinnitus was included among the 10 disorders with the highest PSQI scores in the prior study, consistent with other previous studies, suggesting that patients with tinnitus may need to be treated with a combination of anxiolytic medications to improve sleep and the overall treatment outcome. The majority of trauma patients presenting to the otolaryngology department are acutely traumatized (with

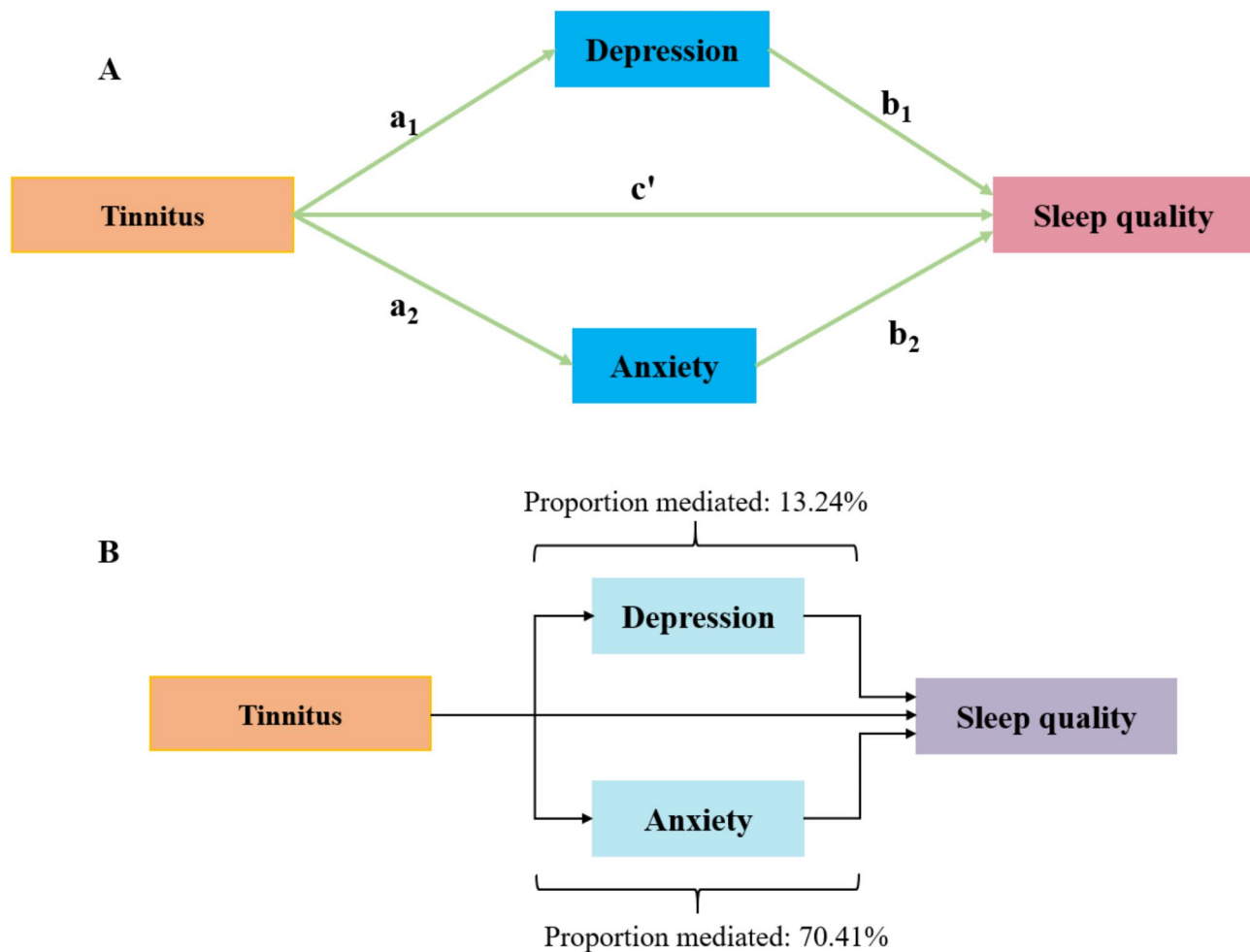


Fig. 4 The mediating effects of anxiety and depression on the relationship between tinnitus and sleep. **(A)** Mediation model framework: mediation models were used to investigate whether anxiety and depression mediated the relationship between sleep quality and tinnitus. The detailed results are reported in Supplementary Table 52. The pathway labelled c' represents the direct effect of tinnitus on sleep quality. The pathways labelled a_i represent the effect of tinnitus on the hypothesized mediators (anxiety and depression). Lastly, the pathways labelled b_i represent the effect of the mediators on sleep quality, calculated while controlling for tinnitus. **(B)** The results of the mediation models. Mediation models were used to investigate the mediating effects of depression and anxiety on the association between tinnitus and sleep disturbance

trauma occurring within the week prior to presentation). In our study, trauma was found to be among the top five outpatient otolaryngology disease categories associated with high SDS, SAS, and PSQI scores. Research has shown that, following trauma, most people experience extreme arousal and emotional distress, accompanied by varying degrees of sleep disturbance and anxiety or depression [26]. Our research findings align well with these observations.

The human pharynx has a dense distribution of nerves and is one of the main channels through which humans come into contact with external stimuli. In patients with persistent stress, lack of sleep, infections, and low immunity, it is often easy to induce discomfort in the throat, including sensations of burning, foreign body, itching, and obstruction. Such patients presenting to the otorhinolaryngology department with symptoms persisting

for more than 3 weeks will usually be diagnosed with chronic laryngitis; however, the correct diagnosis for such patients is abnormal sensation in the pharynx, which can be caused by neurological disorders, physiological or structural factors, and psychological factors [27]. According to our findings, the SDS, SAS and PSQI scores of patients with chronic laryngitis were in the top five among all otolaryngology outpatient disorders, suggesting that psychological interventions could be considered in the treatment of these patients.

The highest SAS scores in this study were found in the 18–45 years age group, possibly due to many of those individuals being in the early stages of their careers, juggling family and work responsibilities, or experiencing intense job competition and high work pressure. The lowest SAS scores were observed in the < 18 years age group, which may be attributed to their having relatively fewer

responsibilities and pressures compared with adults. The same pattern was observed for the SDS scores. The highest PSQI scores were observed in the 45–60 years age group, indicating that the sleep quality of these individuals was generally poorer compared with the other age groups. Men had lower SAS, SDS, and PSQI scores compared with women, consistent with other literature findings [28, 29]. Patients who had a history of smoking and alcohol consumption had higher PSQI scores compared with those who had never smoked or consumed alcohol, in line with other literature findings [30].

In this study, chronic laryngitis, eustachian tube disorders, laryngeal swelling, laryngopharyngeal reflux, neck lymphatic inflammation, snoring, sudden deafness, tinnitus, nasopharyngeal lesions, and trauma were found to have a significant negative impact on PSQI scores, indicating poorer sleep quality in these patients. Chronic tonsillitis, chronic laryngitis, and laryngopharyngeal reflux had a significant negative impact on SDS scores, indicating a higher likelihood of depression in these individuals. Patients with giddiness and tinnitus tended to have higher SAS scores, indicating a higher likelihood of anxiety in these individuals.

The otorhinolaryngology is directly connected to the outside world, and patients with psychological disorders usually show different degrees of sensory abnormalities of the five senses. Clinicians usually pay too much attention to physical disorders and neglect patients' mental status, so we selected otolaryngology outpatients as our study subjects. In our study, we analyzed SAS, SDS and PSQI scores of patients with different outpatient disorders in otorhinolaryngology by using questionnaires collected from patients attending multicenter otorhinolaryngology clinics to assess patients' anxiety, depression, and sleep status in that order. This study can help otolaryngology clinicians to recognize which outpatients are more likely to have comorbid psychologically related disorders, and therefore provide more data to refer to in the diagnosis and treatment of this group of patients. We also performed mediation analysis to explore the effects of different diseases on sleep quality, anxiety, and depression, as well as the underlying mechanisms through which different diseases impact anxiety, depression, and sleep quality. We found that tinnitus can affect patients' sleep quality, with 70.41% of this effect being attributed to anxiety and 13.24% to depression. We also found an effect of sudden deafness on sleep quality, 59.49% of which was mediated by anxiety and 17.12% by depression. Fan et al. performed a dynamic cohort study and drew similar conclusions. They discovered that depression serves as a mediator of the bidirectional relationship between sleep disorders and pain [31]. Therefore, timely psychological counseling can be recommended for patients with these diseases, to

improve their sleep quality and reduce the likelihood of various adverse outcomes caused by poor sleep.

Human beings mainly use subjective senses and sensations, such as taste, smell, vision, hearing, touch, and pain, to contact and communicate with the world. The sensory organs are mainly located in the head and neck, so physical or "psychological" lesions are often accompanied by subjective sensory symptoms. Subjective sensory changes may also lead patients to worry excessively about organ disease and could induce psychological disorders. Most of these patients directly consult an otolaryngology clinic. Therefore, this study used a questionnaire to collect data from patients in multiple otolaryngology outpatient departments. This was deemed more conducive to observing the actual physical and mental illness status of these patients, and the data will serve as a reference for physicians making clinical diagnoses and treatment decisions.

This study has several strengths. First it surveyed otolaryngology outpatients in multiple hospitals, shedding light on the anxiety, depression, and sleep quality of patients with different diseases and uncovering the interaction mechanisms between these diseases and anxiety, depression, and sleep quality. Furthermore, this study provides real-time, long-term observational data that help us understand the progression of these patients' conditions and changes in their psychological status. This could help doctors track disease progression and make timely adjustments to treatment plans. Moreover, by recruiting patients from multiple medical centers in different regions, this study provides broad and comprehensive observational data. The results will help us identify potential trends and differences between regions, serving as a reference for personalized and localized medical services. Additionally, the study adopted a questionnaire survey as an economical and efficient data collection method. Patients could fill out the questionnaire while waiting in line, saving time and resources. Finally, the study holds significance for uncovering the relationships between otolaryngology diseases and sleep quality, anxiety, and depression. It provides a foundation for further research on the impact on psychological health of otolaryngological diseases and could promote attention and awareness among healthcare professionals, possibly leading to further improvement in the overall treatment outcomes of patients.

However, there are also certain limitations to this study. First, as an observational study, the analysis could only establish correlations and not causal relationships; the survey findings pertain to a specific period, and long-term follow-up results are lacking. We intend to follow up on these patients in a subsequent phase and will report our long-term follow-up results in the near future to further substantiate the outcomes of this study. Second, the

data collection methods employed in the study relied on subjective reports and questionnaire responses, posing a risk of memory bias or information distortion. However, we aimed to control for the psychological (including anxiety) status of the researchers, and to mitigate recall bias, while also seeking to use a range of objective indicators to minimize information bias. Moreover, the Body Mass Index (BMI) could potentially influence our results; however, this study did not collect BMI data during questionnaire collection, which is a limitation. In our follow-up study, we plan to focus on otolaryngology inpatients and include observation indices such as BMI and patient efficacy to more comprehensively analyze the relationship between sleep, anxiety, depression status of otolaryngology consultation patients, and their respective conditions. Lastly, the study may not have accounted for all potential influencing factors, which could have affected the accuracy and reliability of the findings. Therefore, caution is needed when interpreting the results, and further rigorous research is required to validate and refine these findings.

In conclusion, many otolaryngological diseases can lead to poor sleep quality and increase the likelihood of depression and anxiety. By uncovering the effects of different diseases on anxiety, depression, and sleep quality, as well as their interaction mechanisms, we aimed to achieve a better understanding of the psychological health status of otolaryngology outpatients with various diseases. This knowledge could allow for more personalized management of otolaryngology outpatients with various diseases. Our findings highlight the importance of a healthy mental state for individuals with different otolaryngological diseases.

Abbreviations

CI	Confidence interval
BMI	Body Mass Index
PSQI	Pittsburgh Sleep Quality Index
SDS	Zung Self-Rating Depression Scale
SAS	Zung Self-Rating Anxiety Scale
SD	Standard Deviation
OR	Odds Ratio

Supplementary Information

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Supplementary Material 1

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Author contributions

JHP, SHZ, and CLQ conceptualized this article and wrote the original draft of the manuscript. CLQ, QYW, and MW contributed to the study design and data collection. LBC, MQS, CW, QBC, TTW, KL, and JLZ contributed to the data collection, methodology, data analysis, and data interpretation. JHP, SHZ, and CLQ reviewed and edited the manuscript. All authors had full access to all the data in the study and had final responsibility for the decision to submit for publication. All authors read and approved the final version of the manuscript.

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Data availability

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Declarations

Ethics approval and consent to participate

The studies involving human participants were reviewed and approved by The First Affiliated Hospital, Zhejiang University School of Medicine, Zhejiang Xin'an International Hospital and Shaoxing Second Hospital. The participants provided oral informed consent to participate in this study.

Consent for publication

Consent for publication was obtained from all participants.

Competing interests

The authors declare no competing interests.

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