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Psychological Effects of Noise Exposure on Personnel in Central Sterile Supply Department in China

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Objective: This study aimed to investigate whether noise exposure in hospital sterile supply centers exacerbated the psychological burden on staff, potentially mediated by concerns about physiological health.

Methods: Between July 5 and August 4, 2023, 308 staffs from central sterile supply departments in 30 hospitals in Hainan were chosen by convenient sampling method. They completed self-administered questionnaires to assess noise exposure status and used the Self-Reporting Inventory-90 to quantify the psychological state of staff across three dimensions: somatization, anxiety, and sleep and diet. Binary logistic regression analysis was used to assess the influencing factors of their psychological symptoms, while a mediation model was used to analyze the pathway of noise affecting psychology.

Results: (1) Predominantly, respondents reported air gun sounds (76.3%) and pressure steam sterilizer noises (78.2%) within central sterile supply departments to be the most troublesome. (2) Approximately 25.33% of participants expressed that their sleep was significantly impacted by noise, while 32.14% expressed concerns about the potential serious effects on their health. (3) Logistic regression analysis revealed that age (OR,1.06, 95% CI, [1.01, 1.11]), educational background (OR, 0.65, 95% CI, [0.49, 0.85]), perceived noise exposure (OR,1.57, 95% CI, [1.04, 2.48]), health concerns (OR, 1.91, 95% CI, [1.06, 3.52]), and hearing loss (OR, 1.46,95% CI [1.02, 2.10]) emerged as significant influencing factors of psychological symptoms. (4) Mediation effect model analysis demonstrated that health concerns (mediation effect value=0.11, 95% CI [0.08, 0.16], Effect ratio=53.83%) mediated the impact of noise affecting psychological state.

Conclusion: Noise exposure represents a concealed risk factor for service quality within hospital central sterile supply departments, with health concerns serving as a mediating factor in the relationship between noise exposure and psychological well-being.

Keywords: exposure to noise, health concerns, mediation effect, psychological state, staff in central sterile supply department, China

Introduction

Noise is defined as sound that causes discomfort or is excessively loud, potentially harming human health.[1] Occupational noise refers to irregular frequency and intensity noise produced during production and work processes, which can cause workers to feel annoyed.[2] Noise is ubiquitous and affects a large global population. According to the 2014 National Health Interview Survey in the United States, 25% of workers had a history of occupational noise exposure, with a point prevalence of 14%.[3] The 2015 European Working Conditions Survey reported that 28% of European workers were exposed to noise for at least a quarter of their working hours, with this proportion reaching 44% in Turkey.[4] A recent occupational hazard factors survey in China showed that 71.95% of workers were exposed to noise, making it the leading occupational health hazard.[5]

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With the development of industrialization and urbanization, noise exposure has become one of the most common global hazards, potentially leading to various physiological and psychological health issues.[6] According to epidemiological studies on noise-induced hearing loss (NIHL), over 450 million people suffer from disabling hearing impairment,[7] with occupational noise exposure being the most common cause of NIHL.[8] Additionally, noise exposure is associated with non-auditory effects, including mental health deterioration, cognitive impairment, sleep disorders, and increased irritability.[9] Recently, researchers have identified noise as an environmental stressor that may negatively affect well-being, quality of life, and attention, potentially triggering emotional reactions. Noise pollution has been confirmed as a risk factor for psychopathology.[10] Additionally, noise pollution comes in various forms, with differing levels of exposure across environments, leading to varying degrees of harm. A British study found that long-term exposure to road traffic noise was associated with an increased incidence of primary hypertension, with the impact being more pronounced in areas with severe air pollution.[11] A Swiss cohort study revealed that the noise threshold for cardiovascular disease mortality risk from road and railway traffic noise was lower than the World Health Organization's recommended environmental noise threshold of 55 dB, with the road traffic noise standard at 53 dB and the railway noise standard at 54 dB.[12]

The physiological and psychological effects of noise exposure in specific workplaces have become a research focus in recent years. The Central Sterile Supply Department (CSSD) in hospitals, responsible for cleaning, disinfecting, sterilizing, and supplying reusable medical instruments, houses numerous large devices that generate noise primarily from aerodynamic, mechanical, and electromagnetic sources.[13] Previous evidence has shown that environmental noise can distract workers and impact their performance.[14] Additionally, noise-induced stress can lead to various physiological symptoms in healthcare workers, such as tachycardia, tinnitus, headaches, and loss of appetite.[15] Long-term exposure to noise can impair the central nervous, endocrine, and cardiovascular systems,[16] causing a range of physical and psychological changes that threaten the well-being of healthcare staff.[17]

While there is substantial literature on healthcare worker health and safety, research on the CSSD has mainly focused on occupational protection, with limited studies addressing the psychological impact of noise exposure on staff. The interaction between noise pollution and both physical and psychological health is complex. It remains unclear whether noise exposure directly affects workers' mental health or whether it exerts an indirect effect through concerns about physical health. This study aims to investigate the impact of noise exposure on CSSD staff, a group facing unique noise conditions in terms of type, intensity, and duration. Current research on the potential health impacts in this specific environment is limited. Therefore, this study seeks to identify high-risk groups and examine whether noise exposure in the CSSD influences psychological health through concerns about physical health. The goal is to explore effective interventions to improve mental health and mitigate the harmful effects of noise pollution on staff.

Objects and Methods

Respondents

The survey targeted workers and staff from central sterile supply departments in 30 secondary medical institutions and hospitals and above in Hainan Province in China from July 5 to August 4, 2023, comprising 18 tertiary hospitals and 12 secondary hospitals by using the convenient sampling method. Inclusion criteria included: ① Those whose shifts had been rotated in three working areas of the central sterile supply department; ② Those who had worked in the central sterile supply department for at least half a year; ③ Those who volunteered to participate in this study with informed consent. According to the hospital's management policy, newly hired employees are required to undergo orientation training and may not be continuously assigned to work in the CSSD. Their subjective experiences may also be influenced by other factors. Therefore, only staff who had worked in the CSSD for more than six months were included in this study. Exclusion criteria was: ① Those who had not worked in any work area within one year; ② Those experiencing emotional changes not attributable to noise exposure during the survey; ③ Those with sleep disorders. All respondents provided informed consent.

Survey Tools

General Situation Questionnaire

A self-designed questionnaire, revised based on the pre-survey, encompassed a total of 9 items, including gender, age, educational background, working years, work unit level and so on.

Noise Environment of Central Sterile Supply Department

With reference to the research conducted by Bai Caiying on the current situation of exposure to noise in pediatric wards and its influence on the physical and psychological health of nurses, the questionnaire content was designed by integrating considerations regarding the working environment of the central sterile supply department.[18] The survey was conducted from three aspects: the current situation of exposure to noise in the central sterile supply department, the subjective cognition of staff regarding exposure to noise, staff self-management of noise exposure, and the measures taken by the hospital to protect against noise exposure.

Self-Reporting Inventory 90 (SCL-90) for Symptoms

From the 10 factors identified in the SCL-90, three factors namely somatization, anxiety, and sleep and diet, were selected to assess the psychological state of the staff.[19] This selection resulted in totally 29 items, where 12 items were about somatization, 10 were about anxiety, and 7 were about sleep and diet. Each item was scored using a five-level scoring system: none (0), mild (1), moderate (2), heavy (3), and serious (4), where a higher score indicated greater severity and impact on the staff. The psychological symptom score is calculated as follows: $S_{\text{psychological symptoms}}$ = (somatization score + anxiety score + sleep/diet score) / 29. If $S_{\text{psychological symptoms}} < 2$, it indicates normal psychological symptoms, whereas if $S_{\text{psychological symptoms}} \geq 2$, it indicates abnormal psychological symptoms.

Sample Size Calculation

To study the effect of noise exposure on the psychological health of staff in the CSSD, we used logistic regression with noise perception as the exposure factor and psychological health status as the outcome variable. The power calculation is based on existing research on the impact of traffic noise exposure on psychological health.[20] In this study, we set Power = 1-β = 0.90, significance level α = 0.05, symptom prevalence $p = 0.15$, and odds ratio (OR) = 1.12.[21] The sample size was calculated as follows: (1) The formula based on a single independent variable is:

$$n = \frac{\left(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta}\right)^2 (p(1-p))}{(\log(OR))^2}$$

where n represents the required sample size, $Z_{1-\alpha/2}$ is the critical value corresponding to significance level α in the standard normal distribution, $Z_{1-\beta}$ is the critical value corresponding to power β in the standard normal distribution, p represents the occurrence rate of the dependent variable in the population, and log(OR) is the logarithm of the odds ratio.

$$n = \frac{(1.96 + 1.28)^2 \times (0.15 \times 0.85)}{(\log(1.12))^2} \approx 105$$

(2) Taking into account the potential loss to follow-up and invalid responses, the sample size was adjusted as follows:

$$n_{\text{real}} = n/(1 - \text{dropout rate}) = 105/0.8 \approx 130$$

(3) To ensure the objectivity and comprehensiveness of the survey data, a total of 350 questionnaires were distributed.

Data Collection and Quality Control Methods

Trained investigators engaged in discussions with department heads to explain the significance of the study and establish trust. Subsequently, the questionnaires were digitized and distributed electronically upon securing consent from department heads. The questionnaire commenced with a clarification of the purpose of the study and the principle of anonymity, stipulating that submission was contingent upon completion of all information. To maintain questionnaire quality,

submissions completed in less than 100 seconds were deemed invalid. Subsequently, two authors collated, proofread, and analyzed the collected questionnaires. Ultimately, 319 questionnaires were collected, with 308 being deemed valid, resulting in a valid questionnaire recovery rate of 96.55%.

Statistical Methods

Statistical analysis was conducted using R version 4.2.3 software. Normally distributed measurement data were presented as mean ± standard deviation, with differences analyzed using independent sample t-tests. For non-normally distributed measurement data, the interquartile range (IQR) method (M[Q1, Q3]) was used, with differences assessed using the Mann–Whitney *U*-test. Counting data were expressed as frequency n (%), with differences analyzed using either by χ^2 test or Kruskal–Wallis *H*-test. A binary logistic regression model was established to identify influencing factors on the psychological state of frontline staff in the central sterile supply department, while a mediation effect model was established to further assess the mediating influence of staff health concerns. By using two-tailed test, a difference of $p<0.05$ was considered statistically significant.

A logistic regression model was established to analyze the factors affecting the psychological state of frontline staff in the CSSD, with perceived noise as the exposure factor and psychological health status as the dependent variable. The model was adjusted for variables such as age, gender, education, years of work in the CSSD, and hearing loss. In this context, β represents the model coefficient, where a larger absolute value indicates a greater influence of the characteristic on the dependent variable. A positive coefficient indicates a positive effect, while a negative coefficient indicates a negative effect. S.E. denotes the standard error of the coefficient, and Z value represents the Z-statistic. OR (95% CI) refers to the odds ratio with a 95% confidence interval, and the p-value indicates the statistical significance of the coefficient.

Additionally, a mediation effect model was established with perceived noise as the independent variable, health distress as the mediating variable, and the comprehensive psychological score as the dependent variable. The model was adjusted for covariates such as age, education, and hearing impairment to analyze whether health distress mediates the impact of noise exposure on psychological symptoms. In this model, the overfit report indicates the model's fit level, F represents the F-statistic of the model fit, and adjusted R^2 describes the extent to which the independent variable explains the variance of the dependent variable. Again, β indicates the model coefficient, t denotes the t-statistic, and the *p*-value indicates the statistical significance of the coefficient.

Quality Control

Through literature review, focus group discussions, and a preliminary survey, a questionnaire addressing the noise environment in central sterile supply departments in Hainan Province was developed. ① Information pertaining to the current status of the noise environment, subjective perceptions, and other relevant aspects was derived from both domestic and international literature sources focusing on noise environments in central sterile supply departments. ② Managers and experts within the field of central sterile supply departments were involved in forming the first draft of the questionnaire through various means of focus group discussions, on-site meetings, Email correspondence, and online discussions.

Pre-Survey

A total of 96 questionnaires were distributed among 15 secondary and higher-level medical institutions for a preliminary survey. Results indicated that the descriptions of noise environments within central sterile supply departments were overly generalized, posing challenges for frontline staff selection and questionnaire consistency. Following extensive deliberation, the study group decided to categorize noise environments into three distinct areas: decontamination area, packaging inspection area, and sterile storage area, for separate assessment, leading to the formulation of the final questionnaire. Subjective perceptions of the noise environment were assessed using a Likert 5-level scoring method, ranging from 1 to 5 points, representing "very quiet" to "very noisy" respectively. In this study, the Cronbach's α coefficient for the scale was found to be 0.877, indicating good internal consistency. The Kaiser-Meyer-Olkin value was 0.850, which is considered acceptable for factor analysis. Additionally, the scale passed the Bartlett's test of sphericity ($p<0.001$), suggesting that the variables are sufficiently correlated for further analysis.

Theory

Noise-Stress Theory

The non-auditory effects caused by noise exposure can be explained by the noise-stress theory. This theory, also known as the noise-induced stress hypothesis, primarily investigates the increase in individual stress and associated health problems resulting from prolonged exposure to high-noise environments. According to this theory, persistent or excessive noise serves as a stressor that activates the body's stress response mechanisms. Over time, this can have adverse effects on both physical and mental health. The key components of the theory include stress responses, chronic exposure, individual differences, health consequences, coping strategies, and environmental impacts.[22]

Social-Psychological Theory

Social-psychological theories play a crucial role in explaining the impact of noise exposure on individual psychology and behavior. These theories not only focus on the direct effects of noise itself but also consider the roles of the social environment and personal characteristics.[23] The primary viewpoints of social psychological theories related to noise exposure are the control theory and the cognitive appraisal theory.

The control theory posits that an individual's sense of control over noise affects their response to it. If a person feels they can manage or reduce the noise, the negative impact on their mental health is likely to diminish. Conversely, if an individual perceives a lack of control over the noise, this sense of helplessness can heighten stress and negative emotions.[24] The cognitive appraisal theory suggests that an individual's cognitive assessment of noise influences their emotional and behavioral responses. If a person views the noise as harmful or unacceptable, they are more likely to experience distress and pressure. On the other hand, if an individual can reframe their perception of the noise as manageable or harmless, their negative reactions may decrease.[25]

Results

General Information of Staff in Central Sterile Supply Department

A total of 308 staff members, comprising 20 males (6.49%) and 288 females (93.51%), who were working within central sterile supply departments were included in this study. The mean age of participants was 41.51 years (SD = 8.12), with an average tenure of 17.91 years (SD = 9.30) in their respective professions, and 7.67 years (SD = 5.73) specifically within central sterile supply departments. Educational attainment varied, with 33 personnel (10.71%) having completed junior high school or below, and 77 (25.00%) possessing a bachelor's degree or higher. Hospital demographics indicated that 207 participants (67.21%) were affiliated with tertiary general hospitals, 27 (8.77%) with tertiary specialized hospitals, and 74 (24.03%) with secondary hospitals. Moreover, 300 respondents (97.40%) were employed by public hospitals. Notably, significant differences were observed in self-reported psychological symptoms regarding age, educational background, years of work experience, and the longest duration of employment in central sterile supply departments ($p<0.05$), as depicted in Table 1.

Current Situation of Exposure to Noise Environment

This section primarily reports the prevailing conditions regarding noise exposure within the surveyed environment: (1) Predominantly, the sound emitted by air guns (76.3%) and pressure steam sterilizers (78.2%) within central sterile supply departments was identified as the most troublesome, with air gun noise (33.1%) being reported as particularly unbearable. (2) Noise interference was most pronounced in the decontamination area, reaching 64.0%, followed by the packaging inspection area at 33.1%. Notably, air gun noise was deemed most unbearable in the decontamination area (40.9%), while pressure steam sterilizer noise was most intolerable in the packaging inspection area (39.6%) and sterile storage area (55.2%). (3) Only 28.2% of hospitals implemented personal protective measures against noise, with just 8.4% of staff receiving hearing protection training. Additionally, only 13.6% of hospitals conducted noise dB testing within their central sterile supply departments, and personnel working in noisy environments for over 7 hours accounted for 37.3% of respondents. Refer to Table 2 for further details.

Table 1 Baseline Characteristics

	Item	Number of People (n=308)	Self-Evaluation of Psychological symptoms: Normal (n=234)	Self-Evaluation of Psychological symptoms: Abnormal (n=74)	*p*-Value
Sex, n (%)	Male	20 (6.49)	15 (6.41)	5 (6.76)	1
	Female	288 (93.51)	219 (93.59)	69 (93.24)	
Age (years)		41.51±8.12	40.86±8.10	43.60±7.91	0.01
Educational background, n (%)	Junior high school or below	33 (10.71)	23 (9.83)	10 (13.51)	0.02
	Senior high school	23 (7.47)	12 (5.13)	11 (14.86)	
	Technical secondary school	68 (22.08)	49 (20.94)	19 (25.68)	
	Junior college	107 (34.74)	86 (36.75)	21 (28.38)	
	Bachelor's degree or above	77 (25.00)	64 (27.35)	13 (17.57)	
Years of working (year)	-	16 (11,26)	15 (11,25)	17 (12,29)	0.09
Years of working in central sterile supply department (year)	-	6 (3,11)	6 (2,11)	7.50 (4,12)	0.04
Maximum working time at noisy places (hour)	-	7 (4,8)	6.5 (4,8)	8 (5,8)	0.00
Level of hospital, n (%)	Tertiary general	207 (67.21)	152 (64.96)	55 (74.32)	0.33
	Tertiary specialized	27 (8.77)	22 (9.40)	5 (6.76)	
	Secondary general hospital or specialized	74 (24.03)	60 (25.64)	14 (18.92)	
Nature of hospital, n (%)	Public	300 (97.40)	227 (97.01)	73 (98.65)	0.72
	Private	8 (2.60)	7 (2.99)	1 (1.35)	

Note: Data are presented as the mean±SD or number.

Self-Management of Noise Exposure by Staff in Central Sterile Supply Department

Subjectively, 61.69% of staff within the CSSD perceived their working environment as noisy. Additionally, 75.65% of respondents expressed concerns regarding the noise levels in their work environment, with 94.48% indicating a necessity for noise reduction measures. Furthermore, 42.21% believed that noise significantly impacted their work, while 25.33% reported severe disturbances to their sleep due to noise. Also 28.90% experienced considerable agitation caused by noise, and 32.14% attributed health issues to noise exposure. Additionally, 35.71% noted an adverse impact on their hearing, with 43.51% being uncertain about potential hearing-related issues resulting from noise exposure. Notably, only 48.70% of respondents expressed satisfaction with their working environment. Refer to Table 3 for further details.

Scores of Psychological State Evaluation Scale for Staff in Central Sterile Supply Department

The self-assessment of the psychological state among staff in the central sterile supply department included three dimensions: subjective physical discomfort, anxiety, and sleep and diet. Notably, subjective physical discomfort obtained the highest average score of (1.76 ± 0.71), while anxiety attained the lowest average score of (1.43 ± 0.62), as indicated in Table 4.

Logistic Regression Analysis of Psychological Symptoms of Staff in Central Sterile Supply Department

Based on the aforementioned univariate analyses, we selected factors that showed statistical significance while also considering their professional relevance. Eleven independent variables were chosen, including age, educational background, years of service at the CSSD, maximum duration of working in noisy environments, perceptions of whether the supply center is quiet, the perceived impact of noise on work, sleep, and health, feelings of irritability, satisfaction with the noise work environment, and whether there is a decline in hearing. The dependent variable was whether the psychological symptoms of the staff were normal or not, forming a binary outcome for the Logistic regression model. The results are presented in Table 5, indicating that age (OR, 1.06, 95% CI, [1.01, 1.11]), educational background (OR, 0.65, 95% CI, [0.49, 0.85]), perception of noise exposure (OR, 1.57, 95% CI, [1.04, 2.48]), health-related distress due to noise (OR, 1.91, 95% CI, [1.06, 3.52]), and decline in hearing (OR, 1.46, 95% CI, [1.02, 2.10]) were significant predictors of psychological symptoms. The R code for the logistic model implementation was shown in eTable 1.

Mediation Effect Analysis of Psychological Symptoms of Staff in Central Sterile Supply Department

In this study, PROCESS macro model 4 was used to examine whether health concerns serve as a mediating factor in the relationship between exposure to noise and psychological symptoms among staff in the central sterile supply department, with age, educational background, and hearing decline considered as adjustment covariates. The results indicated that perceptions of increased noise exposure were associated with greater health-related distress among staff (β=0.46, 95% CI, [0.35, 0.57]), which was significantly positively correlated with psychological symptoms (β=0.10, 95% CI, [0.03,0.16]). Additionally, health-related distress caused by noise positively influenced psychological symptoms (β=0.24, 95% CI, [0.18, 0.30]), as detailed in Table 6, and the R code for the model implementation was shown in eTable 2. The mediation analysis revealed that the mediating effect of health-related distress among staff at the Central Sterile Supply Department was 0.11, with a 95% CI that did not include 0 ([0.08, 0.16]), indicating that this effect accounted for 53.83% of the overall impact. The mediating effect of health-related distress was found to be significant (see Table 7, Figure 1, and the R code for the mediation effect model implementation was shown in eTable 3).

Table 2 Current Situation of Exposure to Noise Environment in Central Sterile Supply Department. [n (%)]

Current Situation of Exposure	Item	Number of People n (%)	Number of People n (%)	
			Tertiary Hospital	Secondary Hospital
What noise in the central sterile supply department (room) do you think disturbs you?[a]	Sound of pressure steam sterilizer	241(78.2%)	178(76.1%)	63(85.1%)
	Sound of air gun	235(76.3%)	184(78.6%)	51(68.9%)
Out of all the sounds here, which one do you find the most unsettling and intolerable?	Sound of air gun	102(33.1%)	85(36.3%)	17(23.0%)
Which of the following instances do you find the most upsetting and intolerable?	Decontamination area	197(64.0%)	156(66.7%)	41(55.4%)
	Packaging inspection area	102(33.1%)	71(30.3%)	31(41.9%)
Among the sounds in the decontamination area, which do you find most unsettling and intolerable?	Sound of air gun	126(40.9%)	104(44.4%)	22(29.7%)
Which sound do you find most upsetting and intolerable in the packaging inspection area?	Sound of pressure steam sterilizer	122(39.6%)	93(39.7%)	29(39.2%)
Which sound do you find most unsettling and intolerable in the sterile storage area?	Sound of pressure steam sterilizer	170(55.2%)	129(55.1%)	41(55.4%)
Have you taken any personal safety precautions against noise in your hospital?	Yes	87(28.2%)	70(29.9%)	17(23.0%)
	No	221(71.8%)	164(70.1%)	57(77.0%)
What are the personal protective measures taken against noise in your hospital?	Wear earplugs at work	51(16.6%)	35(15.0%)	16(21.6%)
	No protective measures	231(75.0%)	171(73.1%)	60(81.1%)
Do you undergo annual training in hearing protection?	Yes	26(8.4%)	19(8.1%)	7(9.5%)
	No	282(91.6%)	215(91.9%)	67(90.5%)
Does your hospital conduct an annual test of noise levels in the central sterile supply department (room) at work?	Yes	42(13.6%)	34(14.5%)	8(10.8%)
	No	266(86.4%)	200(85.5%)	66(89.2%)
How long have you been employed in a noisy environment?	≥7 hours	115(37.3%)	93(39.7%)	22(29.7%)

Note: [a] notes Multi-choice questions.

Table 3 The Psychological Symptoms and Subjective Cognition of the Staff in the Central Sterile Supply Department in Relation to Noise

Subjective Cognition and Psychological Symptoms	Item	Number of People (n=308)	Self-Evaluation of Psychological symptoms: Normal (n=234)	Self-Evaluation of Psychological symptoms: Abnormal (n=74)	*p*-Value
Do you believe your central sterile supply department has a quiet working environment? n, (%)	Very quiet	13 (4.22)	13 (5.56)	0 (0.00)	<0.001
	Quiet	18 (5.84)	17 (7.26)	1 (1.35)	
Are you worried about the noise level in the department of the central sterile supply (room) workspace? n, (%)	Very concerned	128 (41.56)	92 (39.32)	36 (48.65)	0.276
	Concerned	105 (34.09)	79 (33.76)	26 (35.14)	
Do you believe that the central sterile supply department's noise levels need to be decreased? (room)? n, (%)	Very necessary	172 (55.84)	117 (50.00)	55 (74.32)	0.006
	Necessary	119 (38.64)	101 (43.16)	18 (24.32)	
To what extent do you think your work has been impacted by the noise in the central sterile supply department (room)? n, (%)	Serious	88 (28.57)	58 (24.79)	30 (40.54)	<0.001
	Very serious	42 (13.64)	18 (7.69)	24 (32.43)	
To what extent do you think these sounds have interfered with your sleep? n, (%)	Serious	49 (15.91)	29 (12.39)	20 (27.03)	<0.001
	Very serious	29 (9.42)	12 (5.13)	17 (22.97)	
Do the noises in the central sterile supply department make you feel uneasy? n, (%)	Serious	64 (20.78)	36 (15.38)	28 (37.84)	<0.001
	Very serious	25 (8.12)	9 (3.85)	16 (21.62)	
How much do you believe the noise in the central sterile supply department (room) will harm your health? n, (%)	Serious	69 (22.40)	43 (18.38)	26 (35.14)	<0.001
	Very serious	30 (9.74)	9 (3.85)	21 (28.38)	
Are you satisfied with the sound quality in your workplace? n, (%)	Very satisfied	39 (12.66)	35 (14.96)	4 (5.41)	0.001
	Satisfied	111 (36.04)	86 (36.75)	25 (33.78)	
	Average	118 (38.31)	92 (39.32)	26 (35.14)	
Have you experienced hearing loss? n, (%)	Yes	110 (35.71)	62 (26.50)	48 (64.86)	<0.001
	No	64 (20.78)	61 (26.07)	3 (4.05)	
	Unclear	134 (43.51)	111 (47.44)	23 (31.08)	

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Table 4 Psychological State Evaluation Scale Scores for Staff in the Central Sterile Supply Department

Item	Score	Mean Score of Item
Subjective physical discomfort (Somatization)	21.12±8.57	1.76±0.71
Anxiety	14.29±6.22	1.43±0.62
Sleep or diet	10.66±4.11	1.52±0.59
Self-evaluation of psychological symptoms	46.07±17.37	1.59±0.60

Table 5 Logistic Regression Analysis of Psychological Symptoms in the Central Sterile Supply Department

Variable	*β*	SE	Z Value	OR (95% CI)	*p*
Age	0.05	0.02	2.33	1.06 [1.01, 1.11]	0.02
Educational background	−0.43	0.14	−3.15	0.65 [0.49, 0.85]	0.002
Exposure to noise perceived	0.45	0.22	2.05	1.57 [1.04, 2.48]	0.04
Health concerns caused by noise	0.65	0.30	2.12	1.91 [1.06, 3.52]	0.03
Hearing loss	0.38	0.18	2.07	1.46 [1.02, 2.10]	0.04

Notes: SE=standard error; 95% CI=95% confidence interval.

Table 6 Regression Model for Mediation Effect of Psychological Symptoms Among Staff in Central Sterile Supply Department

Regression Model		Overall Fit		Regression Coefficient			
Outcome Variable	Predictors	Adjustment R^2	F	β	95% CI	t	*p*
Health concerns	Age	0.25	26.80***	0.002	[−0.01, 0.01]	0.24	0.81
	Education			0.07	[−0.01, 0.16]	1.63	0.10
	Hearing loss			0.23	[0.11, 0.35]	3.72	<0.001
	Exposure to noise			0.46	[0.35, 0.57]	8.50	<0.001
Psychological symptoms	Age	0.34	32.37***	0.004	[−0.003, 0.01]	1.19	0.24
	Education			−0.07	[−0.12, −0.03]	−3.11	0.002
	Hearing loss			0.07	[0.01, 0.14]	2.24	0.03
	Exposure to noise			0.10	[0.03, 0.16]	3.06	0.002
	Health concerns			0.24	[0.18, 0.30]	8.13	<0.001

Note: ***p<0.001; 95% CI=95% confidence interval.

Table 7 Mediation Effect Analysis of Psychological Symptoms of Employees in the Central Sterile Supply Department

Type of Effect	Value of Effect	SE	Boot-Strap 95% CI	*p*	Mediated Effect Proportion
Direct effect	0.10	0.02	[0.05, 0.15]	<0.001	
Indirect effect	0.11	0.02	[0.08, 0.16]	<0.001	53.83%
Total effects	0.21	0.03	[0.15, 0.27]	<0.001	

Notes: SE=standard error; 95% CI=95% confidence interval.

Discussion

The Staff in the Central Sterile Supply Department are Experiencing Significant Issues Due to the Noise Generated by the Air Gun and Pressure Steam Sterilizer

Given the essential role of the central sterile supply department in managing contaminated medical devices and articles within hospitals, the operation necessitates the use of large-scale equipment and facilities such as automatic cleaning sterilizers, pulsating vacuum pressure sterilizers, ultrasonic cleaning machines, and drying cabinets.[2] Consequently, the concurrent operation of these devices within the same space generates significant noise, with

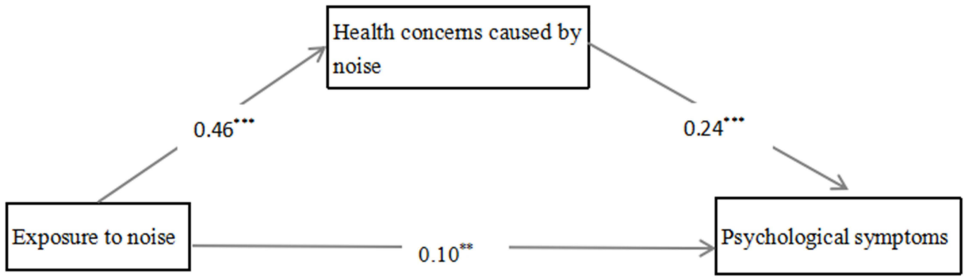

Figure 1 Mediation effect path diagram. ***$p<0.001$, **$p<0.01$.

air guns and pressure steam sterilizers being the predominant sources. Air guns, commonly used for cleaning medical devices, emit loud noises due to their small caliber and high airflow rates, thereby prompting attention to the issue. Efforts to mitigate air gun noise have been assessed, as evidenced by the study conducted by Zhang et al, which proposed a noise and aerosol protection device for pressure air guns, effectively reducing noise levels in the working environment.[26] Pulsating vacuum pressure sterilizers, serving as a fundamental equipment in central sterile supply departments, typically feature double doors, with loading doors positioned in the packaging inspection and sterilization areas, and unloading doors situated in the sterile storage area. Prolonged exposure to high-noise environments not only compromises work quality and efficiency but also may induce staff discomfort and lead to issues such as irritability and tinnitus.[8] These pathological outcomes are primarily attributed to histological and molecular changes induced by noise exposure, including metabolic stress, oxidative stress, inflammation, and DNA damage. Key contributors to NIHL include hair cell loss, synaptic damage, and degeneration of the auditory nerve, with oxidative stress identified as a critical factor in the progression of NIHL. The persistent accumulation of reactive oxygen species caused by noise-induced oxidative stress further contributes to the progression of inflammation, DNA damage, and apoptosis.[27] The interplay of these molecular mechanisms ultimately leads to the deterioration of auditory system function.[6] Therefore, it is necessary to consider the impact of noise within the working environment when designing central sterile supply departments, with the objective of these measures being noise reduction. Such measures include controlling noise propagation through mediums and installing sound insulation equipment. Here are some of the feasible approaches: (1) Enhance the double-layer sound insulation doors and windows of the current building to isolate air transmission and sound energy propagation, (2) Installing mufflers on exhaust fans, (3) Incorporating sound-absorbing materials on indoor and firewall surfaces to eliminate the reverberation effects induced by sound waves, and lastly (4) Relocating compression pumps outdoors while adjusting the distance between packaging tables and sterilizers. Additionally, optimizing equipment operation modes and workflow arrangements is recommended to enhance staff working conditions. Emphasis should be placed on integrating noise attenuation considerations into the standardized layout of central sterile supply departments within the construction of new hospitals, as retrofitting such measures post-completion poses challenges.

Noise Exposure Impacts the Psychological Symptoms of Staff in the Central Sterile Supply Department, Influenced by Factors Such as Age, Education, Health Concerns, and Hearing Loss

Noise, as a form of environmental pollution, can have both physiological and psychological effects on the human body. This study supports that conclusion. A wealth of research indicates that susceptibility to NIHL may be related to both genetic and environmental factors.[28,29] A study by Wang et al revealed that 13.6% of individuals exposed to noise in a central sterilization supply department experienced hearing loss, while up to 27.2% reported feeling emotionally distressed.[30] Research by Sivakumaran et al[31] suggests that exposure to higher levels of noise may increase the risk of short-term or long-term cardiovascular events. As individuals age, physiological functions gradually decline, making older adults more susceptible to health problems and various chronic diseases, such as hypertension and diabetes. In acute and chronic noise experiments

related to the noise/stress hypothesis, changes in stress hormones, such as adrenaline, noradrenaline, cortisol, catecholamines, and steroid hormones, are frequently observed, all of which can impact metabolic processes.[22,] Moreover, well-educated staff tend to have greater access to health knowledge, better health awareness, and healthier lifestyles, which may encourage them to adopt proactive measures to improve environmental factors.[32] Consequently, individuals with higher education levels may experience milder psychological symptoms. A study by Jung et al[33] in a high-noise area of a tertiary hospital's intensive care unit indicated that educational and behavioral interventions could reduce noise exposure levels by an average of 6 dB, leading to decreased noise perception reported by both patients and healthcare workers.

The Impact of Noise Exposure on the Psychological Symptoms of Staff in the Central Sterile Supply Department, Raises Health Concerns

This study found that noise exposure causes health concerns among staff in the central sterilization supply department, which in turn affects psychological symptoms, with a significant mediating effect from health concerns. This reveals a possible pathway through which noise exposure impacts the psychological symptoms of these workers, specifically that health concerns mediate the influence of noise exposure on psychological symptoms. Existing evidence indicates that noise exposure increases the risk of cardiovascular diseases, such as hypertension and heart disease,[34] and is closely linked to mental health mechanisms.[35] Workers who are long-term exposed to high noise environments often worry about their health, leading to distractions in thought and attention, difficulties in face-to-face communication, extended task completion times, and reduced work efficiency.[36] Furthermore, noise acts as a stressor, with prolonged exposure resulting in chronic stress that exacerbates work burdens. These issues can lead to physical discomfort and anxiety, causing emotional fluctuations, feelings of insecurity, and decreased sleep quality.[37] Although the complex relationship and developmental pathways between noise and mental health are not yet fully understood, the findings of this study suggest that health concerns among staff mediate the effects of noise exposure on psychological symptoms. This provides a practical approach for implementing effective interventions to mitigate the impact of noise on the mental health of workers. Management can not only optimize the layout of the CSSD and install soundproofing equipment but also offer health education, mental health support, and counseling services to help staff address their health worries. Such measures can alleviate the stress and anxiety caused by noise, promoting better psychological well-being. Regular health check-ups for employees, particularly hearing assessments, can help identify and address potential noise-related health issues in a timely manner, thereby enhancing the overall physical and mental health of staff.

Limitation

The study included 308 respondents from 30 secondary and tertiary hospitals in Hainan Province, with varying lengths of experience in the central sterile supply department, providing a relatively comprehensive representation of the target population. However, there are several limitations here: (1) The predominance of respondents from tertiary hospitals may introduce bias, as these settings typically boast more refined working environments and regulations compared to secondary hospitals. Adjusting for workload disparities between hospital tiers through weighted allocation of respondents could enhance data objectivity. (2) The study focuses on staff in hospital central sterilization supply departments, and the psychological symptoms reported in this survey mainly include somatization, anxiety, and sleep and dietary issues. It would be beneficial to expand the scope of the study to include a broader range of psychological symptoms. (3) Due to the limited exposure time to noise among new employees, this survey excluded them to eliminate potential confounding factors. However, new staff may lack the necessary training and work experience, making them more susceptible to occupational hazards related to noise. Therefore, investigating the effects of noise exposure on the physical and mental health of new employees presents an intriguing research topic. We will develop a specialized research plan and implementation strategy to explore this aspect further. (4) The assessment of noise exposure primarily relies on the self-reports of the study participants, which can provide a direct reflection of how staff perceive noise and can be useful in studying psychological changes. However, in specific environments, measuring noise levels in dB also holds significance as an objective

metric. (5) While the study was conducted across multiple centers, its cross-sectional design necessitates cautious interpretation of data analysis results. Future research endeavors could benefit from longitudinal group studies to corroborate findings over time. Going forward, it would be prudent to conduct more nuanced investigations, such as subgroup analyses differentiating staff from secondary and tertiary hospitals, or integrating both subjective and objective noise exposure data. These approaches would facilitate a more comprehensive understanding of the causal pathways linking noise exposure to psychological changes.

Conclusion

Noise exposure in the CSSD affects staff self-management and psychological state. Our findings support the noise stress theory, which posits that persistent or excessive noise can act as a stressor, triggering the body's stress response mechanisms and potentially leading to adverse effects on both physical and mental health over time. Furthermore, the survey revealed that health concerns among staff mediate the impact of noise exposure on psychological symptoms. This indicates that staff self-management regarding noise exposure influences their emotional and behavioral responses, aligning with the cognitive appraisal theory. According to the control theory, if individuals feel they can control or reduce noise, the negative impact of noise on their mental health diminishes. Therefore, hospital management should not only focus on improving the architectural layout of the CSSD but also provide appropriate health education and support to mitigate the harmful effects of noise exposure. Noise exposure poses a risk factor for the service quality of the hospital's CSSD. Management should prioritize noise control in the working environment, implement effective measures to protect employees' hearing and mental health, and provide necessary support and protection. This will ensure that staff can work in a healthy environment, maintaining their physical and mental well-being and work efficiency.

Abbreviation

SCL-90, Symptom Check list 90; CSSD, Central sterile supply department; OR, Odds Ratio; LR, Logistic Regression; NIHL, Noise-induced hearing loss; dB, Decibel.

Data Sharing Statement

The data used to support the findings of this study are available from the corresponding author upon request.

Ethics Statements

I confirm that I have read the Editorial Policy pages. This study was conducted with approval from the Ethics Committee of Hainan Medical University. This study was conducted in accordance with the declaration of Helsinki. Written informed consent was obtained from all participants.

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Disclosure

The authors declare that they do not have a conflict of interest.

References

1. Tao YH, Chai YW, Kou LR, Kwan MP. Understanding noise exposure, noise annoyance, and psychological stress: incorporating individual mobility and the temporality of the exposure-effect relationship. *Appl Geogr*. 2020;125:102283. doi:10.1016/j.apgeog.2020.102283

2. de Lima Andrade E, da Cunha E Silva DC, de Lima EA, de Oliveira RA, Zannin PHT, Martins ACG. Environmental noise in hospitals: a systematic review. *Environ Sci Pollut Res Int*. 2021;28(16):19629–19642. doi:10.1007/s11356-021-13211-2
3. Kerns E, Masterson EA, Themann CL, Calvert GM. Cardiovascular conditions, hearing difficulty, and occupational noise exposure within US industries and occupations. *Am J Ind Med*. 2018;61(6):477–491. doi:10.1002/ajim.22833
4. EWCS. Are you exposed to loud noise? (Physical environment) visualisation: European bar chart by: age, All-European Working Conditions Survey Data visualisation. 2012. Accessed Nov 25, 2024. https://www.eurofound.europa.eu/data/european-working-conditionssurvey?locale=EN&dataSource=EWCS2017NW&media=png&width=740&question=Q29b&plot=euBars&countryGroup=linear&subset=agecat_3&subsetValue=All.
5. Editorial Department of Chinese Journal of Labor Health and Occupational Diseases. Survey of occupational disease hazards in China. *Chin J Occupat HealthOccupat Dis*. 2022;40(6):1.
6. Yang L, Gutierrez DE, Guthrie OW. Systemic health effects of noise exposure. *J Toxicol Environ Health B*. 2024;27(1):21–54. doi:10.1080/10937404.2023.2280837
7. WHO. Deafness and hearing loss. 2020. https://www.who.int/en/news-room/fact-sheets/detail/deafness-and-hearing-loss. Accessed Feb 19, 2020.
8. Pretzsch A, Seidler A, Hegewald J. Health Effects of Occupational Noise. *Curr Pollut Rep*. 2021;7(3):344–358. doi:10.1007/s40726-021-00194-4
9. Krittanawong C, Qadeer YK, Hayes RB, et al. Noise Exposure and Cardiovascular Health. *Curr Probl Cardiol*. 2023;48(12):101938. doi:10.1016/j.cpcardiol.2023.101938
10. Tortorella A, Menculini G, Moretti P, et al. New determinants of mental health: the role of noise pollution. A narrative review. *Int Rev Psychiatry*. 2022;34(7–8):783–796. doi:10.1080/09540261.2022.2095200
11. Huang J, Yang T, Gulliver J, et al. Road traffic noise and incidence of primary hypertension. *JACC Adv*. 2023;2(2):1–12. doi:10.1016/j.jacadv.2023.100262
12. Vienneau D, Saucy A, Sch€affer B, et al. Transportation noise exposure and cardiovascular mortality: 15-years of follow-up in a nationwide prospective cohort in Switzerland. *Environ Int*. 2022;158:106974. doi:10.1016/j.envint.2021.106974
13. The National Health and Family Planning Commission of the People's Republic of China WS310.2--2016 hospital Disinfection Supply Center. *Part 2: Technical Operation Specifications for Cleaning, Disinfection and sterilization.Beijing*; 2016.
14. Golmohammadi R, Darvishi E. The combined effects of occupational exposure to noise and other risk factors a systematic review. *Noise Health*. 2019;21(101):125–141. doi:10.4103/nah.NAH_4_18
15. Johansson L, Knutsson S, Bergbom I, Lindahl B. Noise in the ICU patient room Staff knowledge and clinical improvements. *Intens Crit Care Nurs*. 2016;35:1–9. doi:10.1016/j.iccn.2016.02.005
16. Fredriksson S, Li H, Söderberg M, Gyllensten K, Widén S, Persson Waye K. Occupational noise exposure, noise annoyance, hearing-related symptoms, and emotional exhaustion a participatory-based intervention study in preschool and obstetrics care. Arch. *Environ Occup Health*. 2023;78(7–8):423–434. doi:10.1080/19338244.2023.2283010
17. Waye KP, van Kempen E Non-auditory effects of noise: an overview of the state of the science of the 2017–2020 period. In Proceedings of the International Commission on Biological Effects of Noise, Stockholm, Sweden, 14–17 June 2021.
18. Bai C. *Status of Noise Exposure in Pediatric Ward and Its Impact on Physical and Mental Nurses*. Gansu: University of Traditional Chinese Medicine; 2020.
19. Derogatis LR. *SCL-90-R: Administration, Scoring and Procedures Manual*. 3rd ed. Minneapolis, MN: NCS Pearson; 1994.
20. Stansfeld S, Clark C, Smuk M, Gallacher J, Babisch W. Road traffic noise, noise sensitivity, noise annoyance, psychological and physical health and mortality. *Environ Health*. 2021;20(1):32. doi:10.1186/s12940-021-00720-3
21. Lan Y, Roberts H, Kwan MP, Helbich M. Transportation noise exposure. and anxiety: a systematic review and meta-analysis. *Environ Res*. 2020;191:110118. doi:10.1016/j.envres.2020.110118
22. Babisch W. The Noise/Stress Concept, Risk Assessment and Research Needs. *Noise Health*. 2002;4(16):1–11.
23. Fiedler K, Salmen K. Major Theories in Social Psychology. *Oxford Res Encycl Psychol*. 2021;2021:1.
24. Fox Lee S. Psychology's own mindfulness: Ellen Langer and the social politics of scientific interest in "active noticing". *J Hist Behav Sci*. 2019;55(3):216–229. doi:10.1002/jhbs.21975
25. Biggs A, Brough P, Drummond S. Lazarus and Folkman's Psychological Stress and Coping Theory. In: *The Handbook of Stress and Health: A Guide to Research and Practice*. 2017:349–364.
26. Zhang DF, Su Y, Zhang WJ, HY G, Liang Q, Di RQ. Application of a pressure air gun noise and aerosol protection device. *Chin J Disinfect*. 2019;36(11):879–880.
27. Fetoni A, Paciello F, Rolesi R, et al. Targeting dysregulation of redox homeostasis in noise-induced hearing loss: oxidative stress and ROS 420 signaling. *Free Radic Biol*. 2019;135:46–59. doi:10.1016/j.freeradbiomed.2019.02.022
28. Beutel ME, Brähler E, Ernst M, et al. Noise annoyance predicts symptoms of depression, anxiety and sleep disturbance 5 years later. Findings from the Gutenberg Health Study. Eur J Public Health. 2020;30(3):516–521. doi:10.1093/eurpub/ckaa015
29. Armbruster C, Walzer S, Witek S, Ziegler S, Farin-Glattacker E. Noise exposure among staff in intensive care units and the effects of unit-based noise management: a monocentric prospective longitudinal study. *BMC Nurs*. 2023;22(1):460. doi:10.1186/s12912-023-01611-3
30. Wang LZ, Song XM. The Discussion of Occupational Hazard and Measures to the Personnel of the Disinfection and Supply Center. *Chin Foreign Medl Res*. 2016;14(5):147–148.
31. Sivakumaran K, Ritonja JA, Waseem H, et al. Impact of Noise Exposure on Risk of Developing Stress-Related Health Effects Related to the Cardiovascular System: a Systematic Review and Meta-Analysis. *Noise Health*. 2022;24(114):107–129. doi:10.4103/nah.nah_83_21
32. Hahad O, Kuntic M, Al-Kindi S, et al. Noise and mental health: evidence, mechanisms, and consequences. *J Expo Sci Environ Epidemiol*. 2024. doi:10.1038/s41370-024-00642-5
33. Jung S, Kim J, Lee J, Rhee C, Na S, Yoon JH. Assessment of Noise Exposure and Its Characteristics in the Intensive Care Unit of a Tertiary Hospital. *Int J Environ Res Public Health*. 2020;17(13):4670. doi:10.3390/ijerph17134670
34. Jin T, Kosheleva A, Castro E, Qiu X, James P, Schwartz J. Long-term noise exposures and cardiovascular diseases mortality: a study in 5 U.S. *Environ Res*. 2024;245:118092. doi:10.1016/j.envres.2023.118092
35. Srivastava P, Shetty P, Shetty S, Upadya M, Nandan A. Impact of Noise in Operating Theater: a Surgeon's and Anesthesiologist's Perspective. *J Pharm Bioallied Sci*. 2021;13(Suppl 1):S711–S715. doi:10.4103/jpbs.JPBS_656_20

36. Di G, Chen C, Yao Y, Dong L, Wu J. A study on the conversion relationship of noise perceived annoyance and psychoacoustic annoyance a case of substation noise. *J Low Frequency Noise Vib Active Control*. 2022;41(2):810–818. doi:10.1177/14613484211068308
37. Lee Y, Lee S, Lee W. Occupational and Environmental Noise Exposure and Extra-Auditory Effects on Humans: a Systematic Literature Review. *Geohealth*. 2023;7(6):e2023GH000805. doi:10.1029/2023GH000805