ORIGINAL RESEARCH ARTICLE

Non-Auditory Effects of Hospital Noise: A Cross-Sectional Study Among Staff Working in A Tertiary Care Hospital in New Delhi, India

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ABSTRACT

Introduction: Hospital noise is associated with non-auditory symptoms such as stress, sleep disturbances, impaired concentration, and headaches among healthcare staff. These are often classified as quality-of-life issues rather than illnesses. This study aims to assess the prevalence of non-auditory effects of noise and their association with hospital noise levels.

Methods: A cross-sectional study was conducted among 450 staff members at a 1600-bed tertiary care hospital in New Delhi, India. Noise levels were recorded at 30 locations, and data were collected using a pre-tested questionnaire. Multivariable logistic regression analysis was performed to explore associations between noise levels and symptoms.

Results: Sleep disturbance was reported by 75.1% of respondents, vocal fatigue by 73.8%, and impaired concentration by 56.7%. Adjusted analysis revealed significantly higher odds of headache (aOR=2.49, 95% CI: 1.44–4.33), impaired concentration (aOR=2.36, 95% CI: 1.35–4.13), tinnitus (aOR=4.55, 95% CI: 2.36–8.77), and fatigue (aOR=3.14, 95% CI: 1.12–8.77) with noise levels >80 A-weighted decibels(dBA).

Conclusions: Non-auditory effects were prevalent in three-fourths of participants, with worse outcomes at noise levels >80 dBA. These findings underscore the need for policies to mitigate hospital noise and protect staff well-being.

Keywords: Noise, Occupational Noise, Hospital, Health personnel

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Introduction

Noise, defined as unwanted sound, is a recognized health hazard, initially observed in occupational settings where prolonged exposure to loud nose would lead to hearing loss among workers.[1] Exposure to noise levels of 85-90 A-weighted decibels (dBA) continuously can lead to progressive hearing loss, affecting the inner ear mechanisms directly through sound energy impact.[2] However, research has expanded to uncover numerous non-auditory health effects resulting from both short-term and chronic exposure to noise. According to the World Health Organization (WHO), exposure to environmental noise accounts for nearly 1 million disability-adjusted life years in European countries alone.[3] The WHO recommends strict guidelines for noise levels in hospitals, setting limits significantly lower than what is commonly observed.[4] In India, hospitals are designated as silence zones, with noise limits set at 50 dBA during the day and 40 dBA at night within 100 meters of the facility.[5]

Despite these guidelines, hospital noise has been steadily increasing over the past five decades, often exceeding recommended levels by 15-20 dBA.[6] Long-term exposure to noise has significant cardiovascular implications, increasing risks of hypertension, ischemic heart disease, and stroke.[7] It disrupts sleep patterns, leading to daytime sleepiness and cognitive impairment, affecting job performance and overall quality of life among both patients and staff.[8] It has also been linked to increased stress, annoyance, tension headaches, and mental health issues among both these populations.[9,10]

Environmental noise, characterized by factors such as intensity, frequency, duration, and contextual relevance, influences individual responses differently.[8] The sources of hospital noise are diverse and technological advances in healthcare have continued to introduce new sources of noise, complicating the soundscape within hospitals. Mitigating hospital noise not only enhances patient comfort and outcomes but also improves the working environment for healthcare professionals, ultimately supporting better healthcare delivery.[11] Limited research is done on the aspect of non-auditory impacts of noise in Indian health care settings. Hence, this study aims to find the prevalence of self-reported non-auditory symptoms due to noise among hospital staff and its association with hospital noise levels.

Methodology

Study type and site: We conducted a cross-sectional assessment in a tertiary care hospital in Delhi between March-September 2021. 30 sites were selected from indoor and outdoor spaces of the hospital to assess the noise levels and collect data from the staff posted there.[12] This included - i) 7 Outdoor sites (5 entry gates, 1 OPD main entrance gate, 1 emergency entrance gate); ii) 23 Indoor sites (3 medicine wards, 3 surgery wards, 6 obstetrics and gynecology wards, 3 orthopedics wards, 1 Outpatient Department (OPD) atrium, 1 OPD first floor, 1 emergency atrium, 1 emergency room, 2 emergency block wards, 1 sports injury center (SIC) atrium, and 1 super specialty block (SSB) atrium).

Study population and sampling: Our study population included all the staff working in the hospital in any capacity and excluded those who did not work the night shifts during the duration of the study. Night shifts often involve unique environmental conditions, including reduced staffing and patient load, which may influence both noise exposure and its perceived effects. By excluding staff without night shift duties, the study aimed to minimize variability and focus on participants with similar occupational noise exposure patterns across day and night. To calculate sample size, the prevalence of loss of sleep among health care staff was taken at 29.3% as per the study conducted by Khaiwal et al, in 2016, in Chandigarh, India.[13] Accounting for a relative error of 15%, 95% confidence and 10% non-response rate, the sample size was calculated to be 450. A complete list of staff for each site was obtained and 15 participants were recruited per noise recording site using stratified random sampling.

Operational definitions: Leq is the equivalent continuous sound level in decibels, equivalent to the total sound energy measured over a stated period and is also known as the time-average sound level.[14] LAeq is the A-weighted equivalent continuous sound level in decibels measured over a stated period.[14]

Study tools: Noise data was collected using a Digital Integrating Sound Level Meter, Lutron SL-4035SD (International Standards Organisation 9001, Conformité Européene (CE), International Electrotechnical Commission (IEC) 1010) meeting the IEC 61672 class 2 standards. The readings were taken in Decibel, A-weighted (dBA) units representing the sound level measured with the A-weighting network on the sound level meter. A pre-designed, pre-tested, semi-structured questionnaire which was self-administered in English or Hindi and consisted of demographic and work-related information, questions related to symptoms due to noise– headache, sleep disturbance, low concentration, dizziness, tinnitus, vocal fatigue, gastric discomfort and assessment of the stress and anxiety level. The questionnaire was pilot-tested, and content validated by experts (content validity index = 0.80).[15] The Depression, Anxiety, and Stress Scale (DASS 42) standardized questionnaire was used to assess the negative emotional states of depression, anxiety and tension/stress.[16,17]

Data collection: Noise data in the form of LAeq 24 hours was collected at the nursing station and the central location of each ward in the study. It was similarly collected from the outdoor locations. Data was collected on two occasions, on a weekday and a weekend from every site. Where 24-hour monitoring

was not possible, noise recording was done for a minimum of 75% of the daytime (6am-10pm) and nighttime (10pm-6am). Further details on the methodology have been elaborated on previously.[12,15]

Ethical considerations: Ethical approval was obtained from Institute Ethics Committee of Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi (IEC/VMMC/SJH/Thesis/2019-0/01, dated 30.10.2019). Each participant was briefed about the study's objectives by the researcher, and prior written informed consent was obtained. All data were securely stored on a password-protected computer accessible only to the researcher. Data collected were used strictly for academic purposes, and no personal information about participants was disclosed, ensuring the privacy and confidentiality of their information The study findings were utilized to propose strategies for reducing avoidable sources of noise in the hospital, and educational activities were conducted among staff as part of Information, Education and Communication (IEC) initiatives aimed at modifying work practices to mitigate noise levels.

Data analysis: The data was entered and coded in Microsoft Excel and transferred to International Business Machines Corporation (IBM) Statistical Package for the Social Sciences (SPSS) Statistics 21.0 for analysis. Data entry accuracy was ensured through regular validation checks, including random verification of questionnaire entries. Noise levels were categorized based on standard thresholds for workplace safety, and regulations (for commercial areas) and analyzed accordingly (>80dBA, 65-80dBA, <65dBA).[4,5] Statistical analysis included use of Chi-square and Fisher's exact tests for proportions, with a significance level set at $p<0.05$. Additionally, multivariable logistic regression analyses were performed to study the association of non-auditory effects with different noise levels in the hospital setting. Sociodemographic and work profile factors were adjusted for in the multivariable models.

RESULTS

The sociodemographic characteristics of the 450 study participants have been described in detail previously.[12] More than half of the study participants (57.3%) were under 30 years of age [median = 30 years (IQR 27-35)], and two-thirds (66.7%) were male. At least half (51.9%) of the study participants were of graduate level education or higher. Modified Kuppuswamy Scale (2019) was used to assess socioeconomic status, and majority belonged to upper middle (32.9%) and upper class (24.4%).[18] Of the 450 study participants, 158 (35.1%) were security personnel, 122 (27.1%) were doctors, 79 (17.5%) were nurses, 61 (13.6%) were class IV workers, and 30 (6.7%) were data entry operators.

Noise data recording sites and the corresponding workers were classified according to their 24-hour average noise level exposure. During the weekdays, 30 (6%) study participants were exposed to LAeq 24hr of >80 dBA, while 300 (67%) study participants were exposed to LAeq 24hr between 65-80 dBA. During the weekends, none of the sites reported LAeq 24hr >80 dBA, and while 253 (56%) study participants were exposed to LAeq 24hr between 65-80 dBA.

Table 1 lists the various non-auditory effects due to noise and the frequency with which the study participants experience them and perceive them to be due to noise. Sleep disturbance and difficulty to fall asleep due to noise during the night shift were the most common effects reported by 75.1% of the respondents, reported to be "usually" occurring by 198 (44%) and 197 (43.8%) respectively. Tiredness of voice was prevalent in 73.8% with 209 (46.5%) perceiving it to be "usually" due to noise. Impaired concentration and headache were also commonly reported by 56.7% and 42.9% of the study participants, respectively.

DASS scores reported by the study population indicated that 10 (2.2%) of the study population were depressed, 11 (2.4%) were anxious and 30 (6.7%) were stressed. Of these, 2 (0.4%) were moderately depressed, 8 (1.8%) were mildly depressed, 5 (1.1%) were moderately anxious, 6 (1.3%) were mildly anxious, 13 (2.9%) were moderately stressed and 17 (3.8%) were mildly stressed.

Table 1: Distribution of study participants according to frequency of reporting non-auditory effects as perceived to be due to hospital noise (N=450)

Non-auditory symptoms perceived to be due to noise (n, %)	Never	Rarely	Usually
Headache	257 (57.1)	147 (32.7)	46 (10.2)
Impaired Concentration	195 (43.3)	166 (36.9)	89 (19.8)
Dizziness	447 (99.3)	2 (0.4)	1 (0.3)
Gastric Discomfort	438 (97.3)	10 (2.3)	2 (0.4)
Fatigue	414 (92)	32 (7.1)	4 (0.9)
Tinnitus	339 (75.3)	99 (22)	12 (2.7)
Tiredness of voice	118 (26.2)	123 (27.3)	209 (46.4)
Aggressive Behaviour	337 (74.9)	108 (24)	5 (1.1)
Sleep disturbance due to noise during night shift at hospital	112 (24.9)	140 (31.1)	198 (44)
Difficult to fall asleep due to noise during night shift at hospital	112 (24.9)	141 (31.3)	197 (43.8)
Stress due to noise at hospital	409 (90.9)	39 (8.7)	2 (0.4)
Anxiety due to noise at hospital	398 (88.4)	47 (10.5)	5 (1.1)

Table 2: Association of perceiving non-auditory symptoms to be due to noise among study participants with noise levels (N=450)

	LAeq 24h Weekday (in dBA)			p-value*	LAeq 24h Weekend (in dBA)		p-value*
	<65	65-80	>80		<65	65-80	
Headache	38(31.7)	138(46)	17(56.7)	**0.007**	62(31.5)	131(51.8)	**<0.001**
Impaired concentration	54(45)	187(62.3)	14(46.7)	**0.003**	99(50.3)	156(61.7)	**0.017**
Dizziness	2(1.7)	0	1(3.3)	0.057	0	3(1.2)	0.260
Gastric Discomfort	3(2.5)	7(2.3)	2(6.7)	0.302	4(2)	8(3.2)	0.563
Fatigue	8(6.7)	27(9)	1(3.3)	0.460	8(4.1)	28(11.1)	**0.008**
Tinnitus	16(13.3)	84(28)	11(36.7)	**0.001**	39(19.8)	72(28.5)	**0.037**
Tiredness of voice	62(51.7)	247(82.3)	23(76.7)	**<0.001**	135(68.5)	197(77.9)	**0.031**
Aggressive Behaviour	18(15)	82(27.3)	13(43.3)	**0.002**	64(32.5)	49(19.4)	**0.002**
Perceived stress	10(8.3)	25(8.3)	6(20)	0.107	14(7.1)	27(10.7)	0.248
Perceived anxiety	14(11.7)	29(9.7)	9(30)	**0.009**	23(11.7)	29(11.5)	1.000
Sleep disturbance	91(75.8)	231(77)	16(53.3)	**0.022**	146(74.1)	192(75.9)	0.742
Depression (DASS)	4(3.3)	3(1)	3(10)	**0.007**	0	10(4)	**0.003**
Anxiety (DASS)	7(5.8)	4(1.3)	0	**0.022**	3(1.5)	8(3.2)	0.361
Stress (DASS)	10(8.3)	13(4.3)	7(23.3)	**0.001**	11(5.6)	19(7.5)	**0.452**

*Chi-square or Fisher's Exact test as applicable

Table 3: Multivariable logistic regression analysis of association of non-auditory effects perceived to be due to noise with noise levels in hospital (N = 450)

	LAeq 24h Weekday (dBA) (aOR with 95% CI)			LAeq 24h Weekend (dBA)(aOR with 95% CI)	
	<65	65-80	>80	<65	65-80
Headache	Ref	1.35 (0.58-3.11)	2.68 (0.94-7.64)	Ref	**2.49 (1.44-4.33)**
Impaired concentration	Ref	1.77 (0.85-3.69)	1.92 (0.89-3.40)	Ref	**2.36 (1.35-4.13)**
Fatigue	Ref	1.12 (0.8-3.21)	1.78 (0.48-6.9)	Ref	**3.14 (1.12-8.77)**
Tinnitus	Ref	**6.51 (1.98-21.48)**	**4.08 (1.71-9.23)**	Ref	**4.55 (2.36-8.77)**

*Adjusted for marital status, education of participant, socioeconomic status and type of work

Table 2 and Table S1 depicts the association between proportion of study participants perceiving non-auditory symptoms to be due to hospital noise and the noise levels at the hospital during the weekdays and weekend. Headache was significantly more commonly perceived by study participants working in areas with LAeq 24h Weekday >80dBA (56.7%) and 65-80dBA (46%) as well as areas with LAeq 24h Weekend of 65-80dBA (51.8%). Impaired concentration, tinnitus, tiredness of voice, aggressive behaviour, depression (by DASS score) and stress (by DASS score) were significantly more commonly reported at sites with higher noise levels during both the weekdays and the weekends. Fatigue was more commonly reported with higher noise levels during the weekend, while perceived stress, perceived anxiety, sleep disturbance and anxiety (by DASS score) were commonly reported by study participants working at higher noise level sites during the weekdays.

Multivariable logistic regression analysis was done to study the association of non-auditory effects which were significant in the univariate analysis (table 2), with hospital noise level parameters. Adjustment was done for marital status, education of participant, socioeconomic status and type of work. Table 3 depicts the non-auditory effects found to be significantly associated in the adjusted analysis. Study participants exposed to LAeq 24h Weekend of 65-80dBA were significantly more likely to report headache [aOR = 2.49, 95%C.I.-1.44-4.33], impaired concentration [aOR = 2.36, 95%C.I.-1.35-4.13], fatigue [aOR = 3.14, 95%C.I.-1.12-8.77] and tinnitus [aOR = 4.55, 95%C.I.-2.36-8.77].

DISCUSSION

This study provides a unique insight into non-auditory effects due to hospital noise as reported by staff and its association with hospital noise levels. Sleep disturbance, tiredness of voice, impaired concentration and headache were the most reported non-auditory effects which the staff perceived to be due to hospital noise. Headache, impaired concentration, and fatigue were significantly linked to hospital noise levels above the recommended levels set for sensitive, residential and commercial areas by the Central Pollution Control Board as well as the WHO.[4] The findings of this study highlight the need to focus on non-auditory impact of hospital noise on the staff, in addition to auditory effects, and to design and implement interventions to address both aspects.

Globally, several studies have reported noise levels exceeding the recommendations of 50 dBA put forward by WHO. These include studies from Spain, Congo, Taiwan, Korea, England, and India.[13,19-22] In our study, most of the study sites reported noise levels >65dBA during the weekdays and the weekends. This indicates that regardless of health system efficiency, resource allocation or patient load, hospital noise has not been prioritized as a threat to the health of the staff or patients and therefore not been curtailed adequately across the world.

Sleep disturbance has been identified as a non-auditory effect of hospital noise in previous literature. A study conducted by Bevan et al. in England in 2019, found that sleep quality and duration were

poorer in the hospital than at home in both children and their parents.[23] Similarly, patients' self-reports of their sleep quality from a study by Astin et al. found scores for sleep at home to be significantly better as compared to sleep in the hospital, both in terms of quantity and quality.[24] Sleep quality has been reported to deteriorate with increasing noise levels in the hospital, accompanied by an increase in reported sleep disturbances in Iran and Korea.[25,26] In the Indian context, Khaiwal et al. found that 29.3% of the study participants reported a loss of sleep.[13] In the present study, though sleep quality was not scored, questions were asked as to whether study participant's sleep was disturbed due to hospital noise and whether it was difficult to fall asleep in the hospital as compared to at home. In response, 75.1% reported sleep disturbances in the hospital while 89.1% reported no difficulty in sleep at home. The higher equivalent hospital noise levels in our study as compared to existing literature may have contributed to the higher reporting of sleep disturbance at hospital as compared to home.[13,24-26] While the findings were significantly associated with weekday equivalent noise levels (p-value = 0.022), it was not significant in the adjusted analysis. These findings provide evidence that sleep disturbance and difficulty in falling asleep at night, is at least perceived to be a non-auditory effect of hospital noise. Sleep disturbance was not studied in extensive detail in the present study but the findings indicate that further in-depth studies into the area is warranted in the Indian setting.

Jadaan et al. and Costa et al. highlighted impaired concentration and headache as a non-auditory effect of noise in the hospital, reported by more than 43% and 25% of the hospital workers, respectively.[27,28] In the present study, 56.7% reported impaired concentration due to hospital noise [aOR 2.36;95%C.I.-1.35-4.13], while more than half of those working in areas with noise levels >65dBA reported headache due to noise [aOR 2.49;95%C.I.-1.44-4.33]. Similar findings from across the globe add weight to evidence that impaired concentration and headache are significant non-auditory effects of working at high noise levels in the hospital, irrespective of country-level hospital environmental and health-system differences.

Tinnitus has also been identified as a non-auditory effect in previous literature. Park et al. found that 8.9% of study participants reported tinnitus, and it was associated with higher hospital noise levels [aOR = 1.43; p = 0.028].[26] In our study, tinnitus was reported by 24.7% of the participants, and was significantly associated with noise levels of 65-80dBA [aOR 6.51 (95% C.I. 1.98-21.48)] and noise levels >80 dBA [aOR 4.08 (95% C.I. 1.71-9.23)]. The stronger association may be due to higher equivalent noise levels observed in the present study. It may also be linked to higher maximum noise levels in our setting and undetected hearing loss among the study participants, both of which needs to be further explored.

Park et al. also found that participants with higher noise exposures were about twice as likely to be depressed (p < 0.001), stressed (p = 0.038), and anxiety (p = 0.013.[25] The present study also found significant association of noise level with depression (p-value = 0.032) and stress (p-value = 0.008), but there was no statistical significance upon adjusted analysis. Depression, anxiety, stress, and related symptoms in this study were self-reported. Given that the participants were hospital staff, underreporting of these conditions is likely, particularly as a significant portion of the study population comprised doctors and nurses. Additionally, the healthy worker effect may have further contributed to the underreporting of these symptoms.

This is a hospital based cross-sectional study, which utilised a Digital Integrating Sound Level Meter, meeting international standards for noise measurement.[12,15] There is a scarcity of literature on non-auditory effects due to hospital noise in India, and this study adds considerable evidence on the subject matter, highlighting the need for more hospital-based studies to improve our understanding of the Indian context. However, the study also has several limitations. The cross-sectional nature of our study does not allow to make any conclusion regarding the causal nature of any of the non-auditory effects that have been found to be significantly associated with hospital noise level parameters. The study assesses the perception of the study participants and it is impossible to say with absolute certainty that a certain effect is due to noise. Additionally, the study participants are exposed to noise outside the hospital, and while the questions specifically address hospital noise, it is unrealistic to expect participants to fully distinguish between effects attributed to hospital noise and those resulting from noise exposure in other environments. Studying sleep disturbance during night shifts brings up certain ethical questions regarding hospital duties. Although night shifts are primarily work-focused, occasional rest periods due to fatigue accumulated from extended hours or rotational duties are common practice in high-stress environments like hospitals. The study acknowledges these challenges and emphasizes the importance of creating systems and schedules to minimize fatigue and ensure staff well-being without compromising ethical standards or patient care. Finally, the study was carried out during the COVID-19 pandemic, a period when several non-COVID services were disrupted, and patient load in tertiary care hospitals was somewhat lower. This may have led to an underestimation of the noise levels within and around the hospital. Nonetheless, we believe this may have contributed to an overall underestimation of the current scenario.[12]

Conclusion

This study highlights the high prevalence of non-auditory effects of hospital noise among staff, a pattern that is reflected globally, irrespective of socio-

demographic diversity, development status, patient loads or service delivery models.

This indicates the need to earmark hospital noise as an occupational health priority across the world, and especially in India. Current policies fail to address the problems posed by hospital noise to the health of staff, and measures taken to adhere to the regulations set by national and international bodies have been sparse and limited in implementation and effectiveness.

Further research exploring the factors associated with the various non-auditory effects at different levels of the health care system is necessary to gather enough evidence to influence policy change. Increasing awareness among the staff regarding these effects is vital so that these health needs get converted into worker's demands, thereby necessitating action from hospital planning and administration departments.

Author Contributions: AD contributed to all stages, including conception, design, data collection, analysis, and manuscript preparation. **JK** worked on conception, design, and manuscript preparation. **YB** contributed to conception, analysis, and manuscript preparation.

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