

ORIGINAL ARTICLE

Assessment of Noise Annoyance and its Effects on Healthcare Staff Based on Sound Pressure Level and Annoyance Scale

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ABSTRACT

Noise is a common and widespread problem in workplaces. Noise can lead to hearing loss, hypertension, nervous and mental disorders, annoyance and stress, sleep disturbance, negative impact on productivity and working capacity. The undesirable effects of noise on an individual or group are called annoyance. Some personal and social characteristics can affect on annoyance. This study was aimed to assess the level of noise pollution in some hospitals in Qom, central Province of Iran and study its effects on nurses' psychological and physiological responses. The sound levels were measured using a sound level meter and the noise annoyance was assessed through a valid and reliable questionnaire. The noise annoyance index was finally defined based on variables measured by the questionnaire and its correlation with equivalent sound level at different frequencies. Besides, the major noise sources in different wards of the hospitals, the relationship between noise annoyance and demographic and personal characteristics and the effects of noise on sleep disturbance were analyzed. Based on results the average noise level in some hospitals was higher than the national standard in Iran (45 dB (A)). Moreover, in some wards, nurses have experienced different ranges of noise annoyance with obvious signs of it. The finding also indicated that there was a significant relationship between sleep disturbance and noise annoyance ($p < 0.001$). Nurses believed that the noise of patients' families was the most annoying sound source. According to the annoyance index, noise pollution in hospitals can cause psychological effects on staff and be associated with annoyance.

Keywords: *Equivalent sound pressure level, Annoyance, Sleep disturbance, Hospitals*

INTRODUCTION

Noise is considered a common and widespread problem in workplace environments. Health effects of noise pollution, the risk of noise exposure in different

workplaces and its corresponding disorders, have been studied by many researchers. Noise can cause physical and mental effects on humans [1-7]. Temporary and permanent hearing loss, hypertension, cardiac arrhythmia, disorders, conservation interference, annoyance and stress and sleep disturbance, are some of the side effects of noise on humans [5-8]. Noise even in low sound levels can have negative effects on

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concentration, productivity and work capacity and also further increase the risk of accident occurrence. In spite of various measures taken in the past to control noise pollution in workplaces, very little attempts have been made in administrative environments [9-12]. Noise is defined as an unwanted sound that has a close relationship with the physiological concept of annoyance. The unpleasant effects of noise disturbing an individual or a group, is called annoyance. According to researchers, annoyance has roots in a set of personal and social characteristics of individuals. Studies show that noise-induced annoyance increases with raising the sound level. However, in low equivalent sound levels, other factors can determine whether annoyance exists or not. According to some studies, degree of sensitivity to noise and sound level can be important in noise-induced annoyance [10, 13-15]. Various factors affect on noise annoyance which are normally divided into two categories of physical and non-physical. Among physical variables can be pointed to sound level, frequency, temporal variability (fluctuations in loudness or frequency) and tonality, while the experienced sound quality, sound information content, controllability, predictability, the attitude towards noise and its sources, sound necessity and its functionality as well as sound reducibility are amongst the most important non-physical properties [13].

The sensitivity to noise and some individual characteristics such as depression, behavioral stability, being introverted or extroverted, job satisfaction, stress and aggression can affect the annoyance level among different people. The annoyance level is usually evaluated by the subjects' self-reporting, so mental and individual characteristics should be considered in this regard. Age, sex, marital status, work experience and even literacy level are all essential factors for this case. According to the score obtained from individual's self-reporting, annoyance can be categorized in three groups of high, average and slight and sometimes it can be divided into five groups (16 -17). Among the workplaces which have been less noticed are hospitals where there are environmental issues particularly noise pollution. Many noise sources are located inside the hospitals but some outdoor sources can also be effective. Health care staffs, hospital workers, and recipients of various healthcare services are exposed to these sources.

Patients in hospitals need to rest more than any other place and noise can have negative effects on their recovery process. In hospital environments various sources can cause noise in different levels such as paging systems, alarms, air conditioning systems, bed rails, telephones, TVs and employees and visitors' conversation sound. Furthermore, floors, walls and ceilings in hospitals are often very hard and mostly reflect sounds rather than absorb it. The most important outdoor noise source is urban traffic which is inevitable, continuous and unfortunately ever-increasing.

It is noteworthy that noise is the primary cause for sleep disturbance among hospital personnel and patients and increases their anxiety. Sleep disturbance can reduce employee productivity and patients' safety and recovery as well as prolonging hospital stay. Besides, it can decrease the productivity of healthcare workers. Therefore, noise control in hospital environments is of major importance [9, 11, 18]. The US Environmental Protection Agency (US-EPA) has recommended the allowable sound limit in hospitals and patients' rooms as 45dB (A) for daytime and 35 dB (A) at night [9]. According to the standard presented by Iran-DoE, the allowable noise limit for the open space surrounding hospitals and its interior is equal to 55 and 45 dB (A) for daytime and 45 and 35 dB throughout the night, respectively. Noise measurement in hospital environments has shown that the noise level in many cases exceeds the allowable limit. Noise pollution causes increased anxiety, stress and early fatigue among hospital personnel. Bayo et al. conducted a study in a large hospital in Spain. After evaluating the 295 questionnaires filled out by the personnel, they concluded that most of whom believe that the noise level is too high in the hospital and can be interfere with their work performance and affect patients comfort and recovery [19]. Approximately 60% of patients believed that the voice of hospital staff, equipment and other patients cause them sleep disturbance and annoyance [20].

The objective of the current study was to measure and evaluate equivalent sound level and its effects on the personnel of educational and clinical hospitals in Qom City situated in central Iran. Considering the physical and mental effects of noise on hospital personnel and its impact on the quality of service given to patients, it seems that assessing the noise pollution, noise annoyance and identification of the major noise sources in hospitals are of great importance to control such a hazardous factor.

MATERIALS AND METHODS

Studied hospitals

Five hospitals in province of Qom were selected to study. They were the affiliated educational hospitals of Qom University of Medical Sciences. In mentioned hospitals, 100 people from the health care workers in different wards were asked for cooperation.

Measurement of Equivalent sound level (LeqA)

The Leq was measured using a calibrated sound level meter (Model CELL 450). In each hospital, several locations were chosen to measure various noise parameters at different time intervals. The studied locations include wards interiors, the wards of emergency, maternity, infants, surgery, and burns, outpatient waiting area and outpatient hall. Regarding to surface area, all locations were divided to some stations,

Table 1. The Leq_{ave} in separation of different wards of target hospitals

Hospital Code	Wards	Leq_{ave} (dB-A)	Hospital Code	Wards	Leq_{ave} (dB-A)
H1	Maternity and Newborn	67.76	H4	Emergency	74.60
	Intensive Care	65.75		Internal	72.30
	Emergency	68.43		Orthopedics	71.63
H2	Internal	67.09		Psychiatry	67.37
	Intensive Care	63.23		Burning	67.65
H3	Emergency	70.53	H5	Intensive Care	71.47
	Internal	65.67		Emergency	70.67
	Maternity and Newborn	63.32		Internal	68.61

and then the noise level was measured in central point of each station. In order to collect data, a prepared sheet was used to record the characteristics of hospitals such as geographical situation, traffic characteristics as well as other noise sources surrounding the hospitals, type of construction materials and other required data.

Questionnaire survey

In order to study noise-induced annoyance in hospitals, a questionnaire entitled Noise Annoyance Questionnaire of Nurses (NAQN) was prepared. The questionnaire was composed of 73 questions in four different sections by which the personnel's demographic, health, psychological and social data, environmental conditions and personal information were collected and analyzed to evaluate noise-induced annoyance.

The questions were designed to obtain information on sources in hospitals, attitudes towards noise and its effects, noise-induced physical and mental effects, desirability or undesirability of environmental conditions as well as personal characteristics such as being introverted or extroverted). It should be noted that the validity and reliability of the questionnaire was investigated prior to their distribution. For this purpose, 50 trial questionnaires were filled out by nurses in several hospitals. Afterwards, the Cronbach's alpha was calculated by statistical test. It was 0.945 and hence, the reliability of the questionnaires was confirmed. Some experts and informed researcher were asked to study the questionnaire for affirming its validity. Finally, after applying some minor modifications, the questionnaire was finalized to use in further steps. According to the relevant literature, the noise-induced annoyance was determined using the 100-point Noise Annoyance Scale (NAS), based on ISO 15666 standards, used for quantitative assessment of individual sensitivity to noise.

In this scale, based on the obtained score, annoyance is categorized into one of the five groups of without annoyance, slight, average, high or very high. The

points corresponding to each group can be observed in Fig 1 [21].

Statistical Analysis

The data collected from Leq measurements in different stations as well as the information extracted from the questionnaires were entered as inputs to the statistical software. The significance level (P) for the tests was considered 0.05. All statistical analyses were performed by SPSS 18 Software.

RESULTS

Table 1 shows the Leq_{ave} in different wards of the target hospitals. As it can be seen, the Leq_{ave} in Wards Emergency and Internal Surgery are higher than that of others. However, in H5 Hospital, the Intensive Care Wards has a higher noise level compared to the other two mentioned wards. The results showed that the Leq_{ave} in all hospitals exceeded the recommended limit for hospitals (45 dBA) and there was a statistical significant difference ($p < 0.05$) in this case. Furthermore, noise levels in common wards of the target hospitals revealed the significant differences with each other.

The noise annoyance index was studied considering the prevalence of side effects due to noise exposure (Table 2). As it can be seen in Fig.1, there are five ranges to divide the annoyance. According to selected ranges by healthcare workers and their answers to the questionnaire (NAQN), total scores were calculated. Higher scores represent greater noise annoyance. For simple comparison, the obtained means for annoyance can statistically be scored as an index 1 to 5, that "1" indicates not annoyed at all and "5" indicates extremely annoyed. This index can approximate the degree that a person is annoyed by existing noise. It is worth to mention that noise level as well as personal and social characteristics and sensitivity to noise may affect on noise annoyance quantity.

Table 2. Investigation of difference in average prevalence of the noise-induced side effect

Hospital Code	The relative distribution of the prevalence of the noise-induced side effects			The average of the index
	Low	Average	High	
H1	61.1	11.1	27.8	1.81
H2	7.7	46.2	46.2	2.32
H3	8.3	66.7	25	2.34
H4	3.33	46.2	20.5	1.98
H5	17.6	64.7	17.6	2.14

F-value: 2.65

Significant level: 0.038

Table 3. The relative distribution of the annoyance caused by annoying noise sources

Annoying noise sources	Relative distribution of the annoyance caused by annoying noise sources					Average index
	No way	low	Average	Very	Very high	
Conversation of patients' visitors	0	6.1	23.5	36.7	33.7	3.98
Cleaning personnel	2	12.2	31.6	35.7	18.4	3.56
Patients	1	13.3	34.7	31.6	19.4	3.55
Ringtones	4.1	28.6	34.7	19.4	13.3	3.09
Colleagues' conversation	4.1	28.6	31.6	23.5	12.2	3.11
Vehicle traffic	11.3	25.8	30.9	17.5	14.4	2.98
Pager	9.4	26	37.5	13.5	13.5	2.96
Ventilation systems	13.4	30.9	19.6	19.6	16.5	2.95
Medical equipment	5.1	38.8	33.7	12.2	10.2	2.84
Heating and cooling systems	9.2	39.8	29.6	13.3	8.2	2.71
Television and radio	2.16	3.1	5.1	24.5	39.8	2.16

In most hospitals, nurses evaluated the negative effect of noise exposure as average. 61.1% of the respondents in hospital H1 evaluated the prevalence of side effects to be slight, while %27.8 chose the high scale. This hospital had the most percent for "high scale" after hospital H2. The comparison between different hospitals using F-test showed that the prevalence of noise-induced side effects is not the same for those hospitals and therefore, the hypothesis of the prevalence equality was not validated any longer. The noise annoyance index (categorized into ranges of low, average and high) was developed using the scoring scale

and calculating the statistical quartiles. The average of the index was then calculated for better judgments.

The prevalence average of noise-induced side effects was compared separately for demographic and work variables (age, sex, marital status, job experience, daily working hours, and working shift). The prevalence of the side effects between men and women did not show a significant difference ($T=0.319$, $p=0.751$). The same result was obtained for the daily working hours ($F=0.782$, $p=0.507$), marital status ($T=0.062$, $p=0.951$) and working shift (fixed or rotating) ($T=0.596$, $p=0.567$). Although the negative side effects of noise

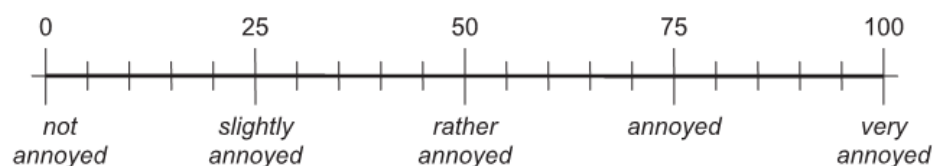
**Fig 1.** the 100-point Noise Annoyance Scale (NAS)

Table 4. The relative distribution of the sleep disturbance caused by annoying noise sources at workplace

Sleep disturbance	Relative distribution of the sleep disturbance caused by annoying noise sources			
	Never	Rarely	usually	always
Disruption in sleep onset in night shift	13.3	38.7	37.3	10.7
Disruption in night sleep onset at home	16.1	47.3	28	8.6
Impaired sleep quality in night shift	16.7	38.5	37.2	7.7
Impaired sleep quality at home	20	40	32.6	7.4

Table 5. The relationship between the Leq and noise-induced annoyance

Dependent variable	Independent Variable (Leq)	
Noise annoyance	correlation coefficient	-0.104
	Significant level	0.306
	Number of observations	99

exposure are intensified with increasing working years, however, nurses with work experience of less than one year, were exempted from this rule. They have suffered from the side effects more than the others. Table 3 demonstrates the relative distribution of noise-annoyance induced by noise sources. Almost %70 of the nurses considered the visitors' voice very or even extremely annoying so that this noise source had the highest average among the other ones. The noise of cleaning and maintenance workers and the patients moaning, crying or speaking were ranked in the next priorities. The comparisons were done regarding the mean annoyance index, as well (Table 3).

The relation between noise annoyance and "awareness about noise side effects on health" was surveyed by the correlation test. The variable of awareness of the side effects is responsible for almost %10 of the variations related to noise annoyance. The results show that noise annoyance has a relationship with the mentioned variable ($p < 0.03$). From the perspective of target society, more awareness about health effects of noise increases the individual susceptibility for annoyance. Based on Table 4, a somewhat similar pattern is observed in the relative distribution of sleep disturbance. Nurses' sleep has been disrupted at home and work (rarely or mostly). The options "never" and "always" hold the proceeding rankings. According to the results, most respondents have chosen the intermediate options.

The correlation test indicated that there was a statistically significant relationship between individuals' sleep disturbance and the level of noise-induced annoyance. The higher the noise annoyance in nurses, the more sleep disturbance for them. As a part of the study, the relationship between lighting and workplace

temperature with the annoyance level was investigated. The correlation test showed that both variables of lighting and temperature are related with noise annoyance ($p < 0.05$). In other words, the more suitable workplace conditions in terms of lighting and temperature will result in less annoyance in nurses and vice versa. Statistical analysis results revealed that there is no significant relationship between Leq and noise annoyance (Table 5). On the other hand, based on the results, the correlation coefficient is rather negative, meaning that annoyance is more in low sound levels in spite of the fact that this relation is not significant from a statistical point of view.

DISCUSSION

The objective of this research was to study the relationship between noise in hospitals and corresponding noise annoyance in nurses. According to the results, the Equivalent sound level in all wards of the hospitals exceeded the recommended allowable sound limit. The highest noise level was reported for the Emergency and Internal Units. These two wards typically have the highest rates of referrals. In Emergency Unit, The screams of patients in the early stages of treatment deteriorate noise intensity of the ward. In a research by El Bardisi, noise pollution assessment was done in several hospitals in Egypt. The finding revealed that the noise level was higher than the allowable limit [11]. Furthermore, according to Bharathan et al., the highest equivalent sound pressure level was experienced in the Emergency and Internal Surgery Wards in the United States [22]. Otenio et al. in Brazil [23] reported similar results in their researches.

In majority of hospitals, the effects of noise exposure have been evaluated to be moderate. Annoyance index was calculated based upon the nurses' complaints against noise side effects and the scores given by them to each of the effects, separately. Considering the scores, the annoyance was divided into the ranges of low, average and high and then the average of the index was calculated. The results from Table 2 demonstrate that the prevalence of the noise induced-side effects have the highest percentage in hospital H2 where in the personnel feel a higher degree of noise annoyance. The wards investigated in this hospital include Emergency, Internal Surgery and Intensive Care Units. Since nurses suffer from higher stress in these wards, psychological factors along with loud noise can further intensify the noise-induced side effects. Due to more medical equipment are used in these wards comparing other ones, more noise is generated, as well. Mechanical ventilation, monitoring devices equipped with sound alarms and infusion pumps, despite being necessary for patients' treatment are considered, in turn, as a cause for intensified noise pollution [24]. Similar results are observed in a research by Chen et al. in 2002 [8]. Morrison et al. in the US showed that louder noise levels along with stress can cause annoyance in healthcare personnel [25]. The comparison between different hospitals showed that the prevalence of the noise-induced side effects is not similar in different hospitals. This can be due to difference in hospital characteristics such as geographical situation, building features, being private or public, the type of services offered, number of beds, personnel tasks and total number of daily receptions. The comparison of the background and working variables (age, sex, marital status, daily working hours and working shifts) on the prevalence of noise adverse effects showed that there is no significant difference between them. The studies on work experience proved that although the prevalence of the negative effects of noise is higher in nurses with more working experience, however, this pattern does not apply to nurses with less than one year of experience so that the incidence rate is the highest in this group of nurses. This could be due to the incompatibility of these individuals with the workplace environment, job stress, unfamiliarity with the working procedures in hospitals and their lower tolerance. Juang et al. showed that an increase in age, daily working hours and work experience has a positive correlation with individuals' sensitivity to noise and in married individuals with an average to high level of work experience, the negative noise-induced site effects are more prevalent [9]. However, such a positive correlation was not observed in the current study. The lack of correlation in the current study can be due to the target society whereas most of the nurses participating in this project were women and single, sharing a similar age range and

mostly young. This could be a confounding factor for the studies related to age, sex and marital status.

Most of the nurses considered the voice of patients' visitors very or extremely annoying so that this noise source had the highest average compared to the other sources while the lowest percentage was assigned to the radio and TV. The conversations between the patients and their family and relatives were the most common noise generating sources in hospitals [12]. The noise caused by conversations between the patients and their visitors, nurses' yelling and the trolley transportation by housekeeping staffs are among highly prioritized noise generation source in hospitals [9]. By studying the participating nurses, it was observed that the individuals who were more aware of the adverse health effects of noise, experienced higher levels of noise annoyance. People who believe that there is too much noise in the environment have more sensitivity to noise [16]. In fact, individuals' attitude towards sound in workplace environments and their awareness play a major role in noise annoyance. Cultural backgrounds, their training against damaging workplace factors and their different levels of noise sensitivity can be the reasons for the positive relationship observed.

According to Table 4, the sleep onset and quality has been disturbed in a high percentage of the nurses at home and workplace. One of the reasons for sleep disturbance in nurses can be shift work. Sleep time disorders and poor sleep quality has often been observed in jobs with shift work. In order to compensate for the lack of sleep during night shifts, it is essential that convenient conditions be prepared throughout the day, otherwise sleep quality will be disrupted. According to El Bardisi and Philimoni as well as USEPA, noise is one of the most important factors causing sleep disturbance in hospital personnel and nursing homes [11-12, 26]. Sleep disturbance of medical care staff include less sleep duration, more time required to fall asleep, increased awakening level and worse sleep quality in comparison with home conditions [27]. Furthermore, the present study shows that more noise annoyance in nurses leads to a higher level of sleep disorder and this correlation is significant. In fact, individuals who are more sensitive to noise are often more annoyed and complained against their sleep disorders. The results show that whatever the workplaces is convenient regarding lighting and temperature, noise annoyance will be less, as well. This result is somewhat predictable because unpleasant work conditions such as poor lighting and air conditioning can be effective in increased occupational stress and dissatisfaction as well as more fatigue intensifying annoyance even more.

According to Table 5, there was no significant relationship between noise levels and noise annoyance. It can be stated that even in low noise levels, other factors such as occupational stress, responsibility towards patients, fatigue and job and workplace

dissatisfaction can increase individuals' sensitivity against noise and in consequence, they will complain about noise annoyance. Based on the results, correlation coefficient demonstrates that annoyance in lower noise levels is higher, however, this relationship is not statistically significant and further data is required for a definite conclusion. Nonetheless, in many studies, researchers have found that noise annoyance is higher in lower noise levels. According to Pedersen et al. [28] low noise levels result in annoyance with a significant relationship. Noise in low levels can lead to disorders in concentration, productivity, work capacity as well as increased incident risk and these factors can subsequently result in noise annoyance. The effects of low noise levels and the required control measures have been less noticed by researchers. Di GQ et al. showed that low noise level (less than 45 dB (A)) as well as low frequencies, have a high potential for noise annoyance [29]. Finally, given the noise levels in the target hospitals exceed the recommended standard limit, it is highly recommended to adopt appropriate control strategies to decrease noise pollution level.

CONCLUSION

Amongst the measures can effectively help solving the noise pollution issue in the hospitals can be pointed out to increased awareness of personnel and hospital managers on the types of workplace noise pollution, adopting administrative regulations and rules, paying more attention to building construction principles and using proper construction material for hospitals, better and convenient air conditioning systems, better maintenance of hospital equipment and assurance of their correct performance, appropriate management of visiting hours on attendance manner of patients' visitors and improvement of hospital environment. Furthermore, it is proposed to study noise annoyance during nighttime and at different working shifts, separately by considering the governing conditions especially night shift. In order to evaluate the effect of demographic variables on noise annoyance, it is necessary to pay enough attention to appropriate distribution of participants regarding their age, sex, marital status and other important variables.

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