Journal of Air Pollution and Health (Spring 2017); 2(2): 87-94

Original Article

Available online at http://japh.tums.ac.ir

NOISE POLLUTION AS A PUBLIC HEALTH CONCERN IN PEDIATRIC HOSPITALS: A CASE STUDY IN TABRIZ, IRAN

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ARTICLE INFORMATION

Article Chronology:

Received 14 April 2017
Revised 17 May 2017
Accepted 19 June 2017
Published 29 June 2017

Keywords:

Noise pollution; public health; pediatric hospital; emergency ward; Tabriz

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ABSTRACT:

Introduction: The increase in noise pollution is a common problem in most countries, raising public health concerns in the workplace. This paper presents the results of a noise survey in different care units of Tabriz Children's Hospital, Iran.

Materials and methods: The present cross- sectional observational research was conducted to assess 24 h noise levels in 5 pediatric care wards (neonatal, infectious, internal, NICU, and emergency) using two TES - 1358 sound level meters in the autumn of 2016. Noise level was measured as maximum level (L_{max}), minimum level (L_{min}), and equalizing level (L_{eq}).

Results: Mean 24 h sound level was the highest in the emergency ward (69.65 ± 1.68). The highest mean sound level in morning, afternoon, and night shifts also belonged to the emergency ward (69.53 ± 0.27, 69.30 ± 0.39, and 69.85 ± 0.43, respectively). There was no significant difference ($P_{value} > 0.05$) in mean sound level in the emergency ward among different work shifts. The highest and most fluctuating noise values were related to the day time, between 10:00 and 17:00 (i.e. including morning and afternoon) in all the wards, except for the emergency ward.

Conclusions: The results of this study demonstrate a noise problem in Tabriz children's hospital. The sound levels measured in all locations and at all times were higher than the recommended levels. This can have an adverse effect on the health of staff and patients, decreasing the professional performance of the personnel in various hospital units. Therefore, the sound level in different units of the hospital should be reduced to the suggested values by implementing effective noise control and prevention measures.

INTRODUCTION

Noise is defined as an unwanted sound that has a close relation to the psychological concept of `annoyance'. It is considered as a public and extensive problem in the workplaces around the world [1, 2]. Noise pollution is increased in most countries as a common problem, raising public health concerns in the workplace [2- 4]. It has

Please cite this article as : Eivazzadeh M, Vahedi S, Asghari Jafarabadi M, Gholampour A. Noise pollution as a public health concern in pediatric hospitals: a case study in Tabriz, Iran. Journal of Air Pollution and Health. 2017; 2(2): 87 - 94

adverse psychological and physiological effects on humans [2, 5- 11], including temporary and permanent hearing loss, hypertension, cardiac arrhythmia, annoyance and stress, sleep disorders, effects on the immune system, and impact on behaviors and mental health [11- 17].

Due to a variety of reasons, noise pollution is important in hospitals [18]. In recent years, considerable attention has been paid to the noise levels in different parts of hospitals [19- 21]. Several studies conducted by World Health Organization (WHO) have shown that the noise level in hospitals has continuously increased since 1960. As hospitals should ensure the safety of patients and staff, the influence of these high levels of noise is a major concern [5]. Noise level in hospitals plays an important role in staff communication and patient recovery [22].

As healthcare institutions, hospitals are affected by various sources of noise pollution which, among others, has negative impacts on the health and comfort of patients and personnel, causes stress among the staff, contributes to staff burn - out, and reduces the speed of wound healing [23, 24]. Telephones, ventilators, alarms, television and electronic entertainment sources, noise-generating beds and other medical equipment, opening and closing of doors, paging systems, staff-patient conversations, overhead fluorescent lights, heating and cooling systems, and running of sink faucets are some examples of noise sources in hospitals [3, 11, 20, 25, 26].

While noise pollution in hospitals is not completely addressed and considered, some guidelines and standards have been established by WHO, EPA, and national organizations in different countries. Noise levels in hospitals should not exceed 45 dB in daytime and 35 dB at night according to the standard of United States Environmental Protection Agency (US EPA) [27]. WHO included guidelines for hospitals in its guidelines for community noise (1995), according to which the average noise level should not exceed 35 dBA in rooms where patients are treated or observed, and 30 dBA in ward rooms [28]. The American Academy of Pediatrics (AAP) has suggested that sound level should not exceed 45 dB in daytime and 35 dB at night. Hourly sound level should not go beyond 50 dB in 10% of daytime (Ln10) or the 1- sec maximum level (L_{max}) of 65 dB [29]. According to the national standard of Iran, the allowed sound limit inside the hospitals equals 45 dBA in daytime, i.e. from 7 A.M. to 10 P.M., and 35 dBA at night, i.e. from 10 P.M. to 7 A.M. [30]. Nevertheless, several studies have shown that the noise level in many hospitals (regardless of their size, type, times of day, days of week, etc.) is usually higher than these recommendations [2, 31- 34].

A low level of noise in hospitals can be a significant competitive advantage, showing an ideal patient environment. However, as competitive activities interest few Iranian state hospitals, the above-mentioned aspect of noise control has been neglected by authors, while attention has been paid to some public health concerns in workplace environments.

This study was thus conducted to measure the 24 h noise level in various care units of Tabriz children's hospital and compare those levels with the recommended standards. Another aim of this study was to investigate differences in noise levels over different nursing shifts during the 24 h work time and among various wards of the noted hospital.

MATERIALS AND METHODS

Studied area

Tabriz children's hospital (Iran) which is an educational hospital affiliated with Tabriz University of Medical Sciences was selected for the present cross - sectional observational study which was conducted to assess noise levels in 5 special pediatric care wards: neonatal, infectious, internal, neonatal intensive care ward (NICU), and emergency.

Measuring sound level

In order to measure the sound level in various wards of the hospital, two TES - 1358 sound level meters were used. The sound level meters were set at A - weighting, slow time constant, and 30

dB gain, allowing for the range of 30 dB to 130 dB SPL. Measuring stations were selected according to ISO 9612 Standard. To this end, three locations (nurses' station, ward interiors, and patient rooms) were selected in the mentioned wards. Sound measurement was performed at the heights of 1.5 and 1 m from the earth in nurses' station and patient rooms, respectively.

In each station, 24 h L_{eg} (equivalent continuous sound pressure level), 24 h L_{max} (maximum A-weighted sound level), and 24 h L_{min} (minimum A - weighted sound level) were measured during three days in the autumn of 2016. The measurements were made using 60 min time averaging.

To ensure the accuracy of the data, the measuring devices were calibrated using the supplied 94 dB calibration device (accurate to within ± 0.1 dB) every day before use. In order to account for diversity, the measuring days were scattered over an entire week, except for the holidays.

Statistical analysis

The data resulting from sound level measurements were analyzed in SPSS 17 (SPSS Inc., Il, Chicago, USA). Descriptive statistics were employed for the measured noise levels. The means and the patterns of sound level in the studied wards were obtained and compared with one other. One-way ANOVA was run to identify statistically significant differences in sound level among different wards and among different working shifts (i.e. morning, afternoon, and night). Differences were considered significant for $P_{value} < 0.05$.

RESULTS AND DISCUSSION

Table 1 shows the statistical analysis of the 24 h sound level in various wards. According to the data, the level of Leq was 69.44 - 69.81 dB in the emergency ward, which was the highest among all the wards (69.65 ± 1.68 dB, 95 % CL). Moreover, in comparison with other wards, mean 24 h L_{max} and 24 h L_{min} (94.43 and 50.43, respectively) were the highest in the emergency ward. In addition, the lowest mean of Leq, L_{max} and L_{min} belonged to the NICU, neonatal, and internal wards, respectively. Results revealed that L_{eg} in all wards of Tabriz Children's Hospital is 30- 45 dBA and 15– 30 dBA higher than WHO guideline and national standards, respectively.

Based on t - test, compared with national sound level standards, mean sound levels were about 24.63, 15.45, 21.37, 17.30, and 19.26 dB higher than the standard limitation, i.e. 45 dB (A), in the emergency unit (95 % CL: 24.44, 24.81), NICU (95 % CL: 15.08, 15.82), internal unit (95 % CL: 20.84, 21.90), neonatal unit (95 % CL: 16.82, 17.77), and infectious unit (95 % CL: 18.84, 19.68). The measured sound levels significantly exceeded the WHO standard by at least 15.45 dB (A) on average levels, and by at least 40.68 dB (A) on L_{max}. Significant differences among different wards were identified by ANOVA (F - ratio = 319.295, $P_{value} < 0.05$).

The trend of noise levels in hospitals around the world has consistently been rising since 1960 by approximately 0.38 dB / year for daytime levels, and approximately 0.42 dB / year for nighttime

Table1. Statistical analysis of 24 h A - weighted equivalent sound pressure levels (dBA) in various wards of the hospital

Ward	L_{eq}	L_{max}	L_{min}
	Mean ± SD	Mean ± SD	Mean ± SD
NICU	60.45 ± 0.88	88.03 ± 0.59	47.15 ± 2.97
Neonatal	62.30 ± 1.12	85.68 ± 3.05	47.63 ± 1.65
Infectious	64.27 ± 0.99	90.63 ± 6.33	43.20 ± 1.59
Internal	66.37 ± 1.25	93.35 ± 5.53	39.45 ± 3.89
Emergency	69.63 ± 0.44	94.43 ± 4.98	50.43 ± 0.84

levels [18]. Thus, noise pollution in hospitals is a universal problem and noise control techniques should be adopted to reduce the noted adverse effects.

Table 2 presents the statistical analysis of sound level in various wards during morning, afternoon, and night shifts. The results indicate that the highest mean sound level belonged to the emergency ward (69.53 ± 0.27, 69.30 ± 0.39, and 69.85 ± 0.43 for morning, afternoon, and night shifts, respectively). Furthermore, the lowest mean sound level was related to the NICU (59.98 ± 0.96, 61.53 ± 0.29, and 60.15 ± 0.57 for morning, afternoon, and night shifts, respectively). The results of one-way ANOVA revealed that the sound level significantly differed over the shifts in all the wards ($P_{value} < 0.05$).

Fig. 1 represents mean Leq on the three working shifts across different wards. According to Fig. 1, mean Leq in all the wards exceeded the suggested national and international (WHO, EPA, and AAP) limitation for hospitals (45 dBA). No location complied with the current WHO guidelines and national standards, and a review of objective data indicates that this is true for hospitals around the world.

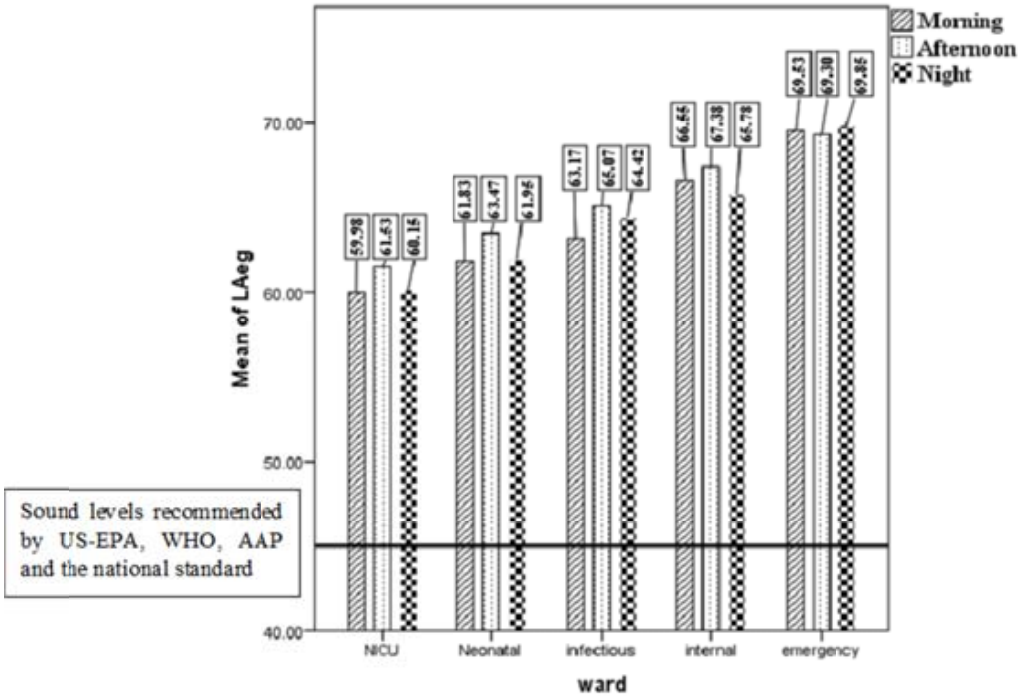

Fig. 1. Logarithmic average A - weighted sound pressure levels measured in different wards on three shifts compared with guidelines

Table 2. Statistical analysis of sound level (dBA) on different shifts

Shift		NICU	Neonatal	Infectious	Internal	Emergency
Morning	Mean ± SD	59.98 ± 0.96	61.83 ± 1.66	63.17 ± 0.66	66.55 ± 1.96	69.53 ± 0.27
	95 % CL	58.97 - 60.99	60.09 - 63.58	62.47 - 63.86	64.50 - 68.60	69.25 - 69.82
Afternoon	Mean ± SD	61.53 ± 0.29	63.47 ± 0.56	65.07 ± 0.82	67.38 ± 0.86	69.30 ± 0.39
	95% CL	61.22 - 61.84	62.88 - 64.05	64.20 - 65.93	66.48 - 68.28	68.89 - 69.71
Night	Mean ± SD	60.15 ± 0.57	61.95 ± 0.52	64.41 ± 0.71	65.78 ± 0.50	69.85 ± 0.43
	95 % CL	59.80 - 60.50	61.62 - 62.28	63.96 - 64.87	65.46 - 66.10	69.58 - 70.12

In addition, in all the wards except for the emergency ward, mean sound level was the highest on the afternoon shift. Moreover, lowest mean sound level in all the wards, except for the emergency ward, belonged to the morning shift. However, there were minimal differences among sound levels on various shifts across the 5 ward. Based on ANOVA, there was no significant difference ($P_{value} > 0.05$) in mean sound level in the emergency ward during different shifts.

Table 3 illustrates the variation of noise levels and means according to the time of day and the wards. The comparison of noise levels over 24 h in different wards showed that the trends of sound level variation are the same in all wards, except for the emergency ward. Sound levels remained steady in the lowest value from 7:30 to 10:00, after which they gradually increased until 17:00, and then decreased slowly from 17:30 to 7:30. On the contrary, the variation of sound level in the emergency ward was unique. Here, sound levels increased during night from 19:30 to 6:00. Fig. 2 summarizes the data depicted in 24 h measurements by averaging the levels found in all five units. The results show that the highest and most fluctuating noise values accrued during the daytime were related to the period between 10:00 and 17:00 (i.e. morning and afternoon) in all wards except for the emergency ward. By contrast, the lowest noise values, i.e. the quiet period, occurred between 17:30 and 10:30, which was, nevertheless, only about 2 - 5 dB quieter than the noisy time of the day.

Based on Fig. 2, there is less than 5 dB of variation and fluctuation from the lowest to the highest sound pressure level in all the wards. The highest variation of sound pressure level (about 5 dB) was related to the internal ward. By contrast, the emergency ward had the lowest (about 1 dB) variation of sound pressure level during 24 h of daytime and was noisy all day.

Table 3. Variation of L_{eq} according to the time of day and shifts

Shift	Time	NICU		Neonatal		Infectious		Internal		Emergency	
		LA eq,1 h (dBA)	Mean	LA eq,1 h (dBA)	Mean	LA eq,1 h (dBA)	Mean	LA eq,1 h (dBA)	Mean	LA eq,1 h (dBA)	Mean
Morning	7.30	59.4	59.98	61	61.83	63.1	63.17	65	66.55	69.6	69.53
	8.30	59.4		60.8		62.9		65.4		69.5	
	9.30	59.4		60.3		62.9		65.4		69.7	
	10.30	59.3		61		62.8		65.5		69.7	
	11.30	60.9		63.8		62.8		68.3		69.7	
	12.30	61.5		64.1		64.5		69.7		69	
Afternoon	13.30	62	61.53	64.5	63.47	64.2	65.05	68.6	67.38	68.5	69.30
	14.30	61.7		63.7		64.4		68.2		69.5	
	15.30	61.6		63.1		64.4		67.4		69.5	
	16.30	61.4		63.3		66		67		69.4	
	17.30	61.3		63.1		65.9		66.6		69.5	
	18.30	61.2		63.1		65.5		66.5		69.4	
Night	19.30	61.1	60.15	62.6	61.95	65.2	64.41	66.5	65.78	69.5	69.85
	20.30	60.9		62.7		65.2		66.2		69.7	
	21.30	60.7		62.5		65.1		65.9		69.6	
	22.30	60.5		62.4		65.1		66		69.6	
	23.30	60.3		62		64.9		66.3		69.9	
	0.30	60.2		62.1		64.7		66.2		69	
	1.30	60		61.9		64.4		65.9		69.9	
	2.30	59.8		61.7		64.1		65.7		70.5	
	3.30	59.7		61.6		63.9		65.4		70.5	
	4.30	59.6		61.5		63.7		65.2		70.2	
	5.30	59.5		61.3		63.4		65		70	
	6.30	59.5		61.1		63.3		65.1		69.8	

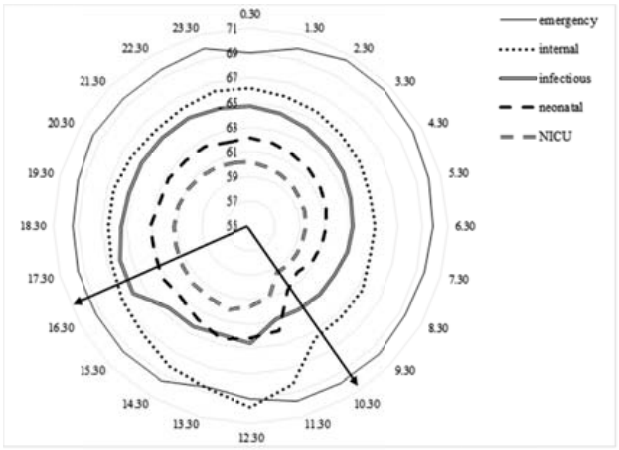

Fig. 2. A- weighted equivalent sound pressure levels measured in various wards according to the time of day

The results mainly demonstrate the existence of a noise problem in Tabriz children's hospital and suggest that this problem probably exists in all modern hospitals. This research showed that the highest mean Leq, L_{max}, and L_{min} belonged to the emergency unit. One of the factors contributing to the noise in hospitals is human activities. The higher sound level in this part of the hospital can be due to factor such as the large number of patients referred to this unit, screaming and crying patients in the early stages of treatment, and patient entourage [35, 36].

When the sound level is higher than 60 dB, many medications are required for surgical patients in recovery [37]. Moreover, it was reported delays in wound treatment in some animals when noise was present [38]. Several studies reported the highest sound level in emergency units, which is consistent with the present study [36, 39-41]. Also, the low mean L_{eq} in the NICU may be related to factors such as the specialized nature of the ward, lack of a companion for patients, increased quality of service to patients, and quick response of nurses to alarm devices. An study in Turkish hospitals also revealed that the sound level was far less in special wards than other units [42].

Our results showed that the highest sound level occurs during afternoon shifts in all wards, except for the emergency ward, which can be due to the changing of shifts, nurses visiting patients, visitors or patients' family members talking, food being served, etc. These results correspond with other studies [22, 26, 35, 43].

Although noise levels decreased during the night, they were still constantly above the night time level recommended by WHO, i.e. 30 dB. It was illustrated by many researchers that the sound level in the emergency ward was above the limit of Australian national sound standard from 21:00 to 6:00 [44].

The results of statistical analysis showed that there was no significant difference in the sound level in the emergency ward among different shifts. This can be due to the working procedure of this ward compared to other wards, as the emergency care unit does not have a specific time for treatment activities and clinical operations take place on demand all day. In 2009, noise pollution was examined in intensive care units (ICUs) and emergency wards in Imam Reza teaching hospital, Mashhad, Iran, and identified no particular time pattern for noise variation because of the all- day nature of procedures in the emergency unit [45].

The highest and most fluctuating sound level in all the wards, except for the emergency unit, occurred during the day time from 10:00 to 17:00. The increase in sound level changes in this period can be due to activates such as visiting and feeding times, visitors or patients' family members talking, the presence of social workers, examination of patients, and peak periods of office work and staff. The study on the sound level in the ICUs of a public university hospital in Santa Marta (Colombia) showed that various activities such as changing of shifts, visiting, and feeding the patient can cause an increase in the level of sound in the ICU [35].

CONCLUSIONS

The results indicate that the average sound level in all the wards is higher than the levels recommended by US- EPA, WHO, AAP, and Iranian national standards. The measured sound levels are high enough to interfere with, among others, the health of staff and patients, professional performance of personnel, sleep, and speech intelli-

gibility. Accordingly, in order to promote a safer environment for patients and hospital staff, sound level should be reduced to the recommended levels by implementing effective noise control and prevention measures in various hospital units.
Pediatric care requires a suitable environment that enhances growth and recovery. Reducing sound pollution in the hospital's environment is an important part of this care. As a result, further research is needed to determine the appropriate sound level which promotes tranquility.

FINANCIAL SUPPORTS

The authors would like to thank the facility supported by Department of Environmental Health Engineering, Tabriz University of Medical Sciences.

COMPETING INTERESTS

The Authors declare that there is no conflict of interest.

AUTHOR'S CONTRIBUTIONS

All the authors contributed to the design of the study as well as the review and revision of the paper and have approved the final version of the paper. All authors contributed equally in the preparation of this manuscript.

ACKNOWLEDGEMENTS

The authors would like to acknowledge Tabriz children's Hospital, Tabriz University of Medical Sciences, for providing the research feasibilities.

ETHICAL CONSIDERATIONS

There are no ethical considerations in this article.

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