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Original Article

Assessing the influence of noise levels on medication errors of nurses in a hospital in Kashan, Iran

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Abstract

***Background & Aims*:** Noise exposure can impact nurses' performance and may result in disruptions to their tasks. This study aimed to examine the correlation between the average equivalent sound level and the occurrence of medication errors.

***Materials & Methods*:** This cross-sectional study involved 150 nurses in Iran in 2020. First, two medical and two surgical wards were randomly selected using a coin toss method. Second, the nurses who worked in those wards were sampled using the convenience method. Nurses' medication errors were assessed using a questionnaire. A sound level meter was used to measure the sound level in decibel. Data were analyzed using analytical tests, including Kruskal-Wallis, Spearman correlation coefficient, and Poisson model.

***Results*:** The mean sound equivalent level in the cardio-respiratory internal ward (58.94 ± 1.88) was higher than the same level in the other internal and surgical wards ($p < 0.001$). An increase in the mean sound equivalent level in the wards was accompanied by an increase in the mean number of medication errors among unmarried individuals ($e^{0.22} = 1.25$), which was 1.25 times more than the errors made by married individuals. Finally, an increase in age and the mean sound equivalent level resulted in the occurrence of medication errors ($p < 0.002$).

***Conclusion*:** The results showed that there was no relationship between the sound pressure level and nurses' medication errors in the research environment. Therefore, it is necessary to conduct more studies to investigate the factors that increase the incidence of medication errors.

***Keywords*:** Medication errors, Noise pollution; Nurse

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Introduction

Noise pollution is defined as the intensity of sound that annoys humans, causes hearing damage, and results in their arousal (1). Studies have shown that frequent exposure to sounds with an intensity higher than 80 decibels has harmful effects on human health (2). Hospitals are considered relaxing places for patients. Nonetheless, the results of some studies have shown that they are among the places where the mean sound equivalent level is observed in abundance (3, 4). A study reported that the mean sound levels in hospitals were about 72 dB and 60 dB during the day and night, respectively. These levels are considered to be the levels of pollution based on the standard of the World Health Organization (WHO) and can cause problems for hospitalized patients (5, 6). Hashemi et al.'s study showed that the level of sound pollution in Iranian hospitals was higher than the national standard values (6). The standard limit was reported based on the nurses' opinions. That is, the sound exceeded this limit when more than 76% of nurses considered its volume in the ward to be high and annoying, and 34% to 45% of nurses from different wards reported that it caused irritability, headaches, and decreased their concentration (7). Notwithstanding, the effects of this sound equivalent level on the nurses' behavior and care performance have received less attention (5, 8).

Nightingale believes that noise pollution negatively affects the quality of care and can have adverse effects on both patients and other attendees in the hospital environment (9). The results of Ryherd et al.'s study showed that 91% of nurses believed that noise pollution affected their performance and disrupted their activity (10). On the contrary, Terzi et al. reported that low noise levels increased the quality of patient care, reduced nurses' job burnout, and decreased the nurses' tendency to change jobs (11). Costa et al. reported that nurses who worked in noisy environments were more likely to experience behavioral changes and commit more medication errors in their performance (7). Likewise, Ornelas-Aguirre et al. examined the effect of noise on the intensive care unit and concluded that the increased levels of noise disrupted the nurses' concentration, adversely affected their interactions, caused a delay in their recognition of alarms and their responses to them, increased their medication errors, and endangered the patients' safety (12).

Providing nursing care and following medication orders constitute important parts of the treatment and patient care process (12). Nursing errors include: failure to carefully examine the patients and record their history, failure to prepare the patients' history and to report their changes, failure to provide the treatment in an accurate way, failure to evaluate patients' care and to record it on time, failure to report to doctors on time regarding the patients' status, failure to prevent patient falls, failure to observe the patients and record the relevant observations correctly, failure to use standard equipment resulting in burns or injuries to the patients, failure to maintain patients' confidential information, and failure to avoid errors in recording the nursing reports (13). Medication errors constitute an important category among the most common known nursing errors (7, 13). A study in seven educational hospitals in Iran showed that noise pollution ranked as the 14th factor among the causes of nursing errors (14). On the other hand, another study showed environmental factors as the leading category causing medication errors, with low light and noise pollution ranking highest among these environmental factors that resulted in the above-mentioned errors (15). Nonetheless, in a study which was conducted in several hospitals in Tehran, none of the surveyed nurses mentioned noise pollution as one of the factors that affected their medication errors (16). The results of Pereira et al.'s study showed that there was no significant relationship between noise pollution and medication errors (drug dose, drug type) (17). Furthermore, a study, which was carried out in Ethiopia, showed that lack of experience, lack of personnel, and nursing shifts were major factors which influenced the commitment of medication errors. Notwithstanding, this study did not mention noise pollution as an important and effective factor in the occurrence of medication errors (18). Considering the conflicting results of studies regarding the relationship between noise pollution and medication errors, there is a need to examine the correlation between hospital ward noise pollution and nurses' medication errors. Moreover, there is a need to determine the degree to which the severity of contamination is related to the frequency of medication errors. Therefore, the importance of preventing and reducing these errors, along with the lack of information about the noise pollution status at Shahid-Beheshti Hospital in Kashan, the lack of previous studies in this field, and the lack of information about the relationship between the intensity of noise and the rate of nursing medication errors, motivated the researchers to conduct the present study to determine the relationship between mean sound equivalent level and the rate of nursing medication errors.

Materials & Methods

The present study was a cross-sectional study and involved all of the nurses who worked in the medical and surgical wards of Shahid-Beheshti Hospital in Kashan in 2019. In order to select the participants, first, the desired wards were randomly selected from among all of the wards, using the lottery method. Then, all the nurses who worked in these wards were selected with the help of the census method. More specifically, at the first stage, two wards were randomly selected from among the four medical wards using the lottery method. Likewise, two wards were selected from among the four surgical wards using the same method.

The sample size was determined using the formula for estimating a quantitative trait in the society, as based on the results of the study which was conducted by Joolaee et al. (19). In this study, 150 nurses were selected as the participants based on the following values: standard deviation = 4.14, d = 0.12, and Z = 1.96.

$$n = \frac{\left(z_{1-{}^{a}/_{2}}\,\delta\right)^2}{(d)^2} = 150$$

The inclusion criteria involved: working full-time in the wards, having a bachelor's degree in nursing, and having a minimum of one year of work experience. On the other hand, the exclusion criteria involved: being unwilling to continue to participate in the study and being transferred to other wards during the shift.

First, the first researcher provided two other research assistants with training in medication error investigation. Second, this researcher tested their qualifications and confirmed their capability to observe and to collect data based on the research checklist. Third, the researcher asked each of these people to observe and to collect data on medication errors during one morning, one evening, and one-night shift. Accordingly, the assistants attended the ward during the morning and evening shifts, and observed each nurse's medicinal actions. On the night shift, the observation was made only at the time when the medication is usually given to the patients. This time period involved 5:30 a.m. to 6:30 a.m. in the morning and 22:00 to midnight. Each nurse was observed during drug administration. The data on the medication errors were collected with the help of direct observation and a review of medical records and cards.

The research tools included a sound meter, the other part of the demographic information questionnaire, and the medication errors checklist. A CEL-450 and CEL-490 sound measuring device, which was made in England and evaluated the sound in decibels, was used to measure the sound intensity in the selected sections. The device was installed at the nursing station at a height of 2 meters from the ground and in a part that was not covered by any special object. The sound evaluation during 24 hours in the ward was the mean of the sounds recorded by the device. International and national standards in Iran allow sound limits for open spaces around and inside hospitals during the day, from 7 to 10 p.m., which are equal to 55 and 45 dB, respectively. Moreover, they allow sound limits at night from 22:00 to 07:00 that are equal to 35 and 45 decibels, respectively. Therefore, sound levels above these values were considered noise pollution. In each of the selected sections, the sound intensity was checked on all days of the week. The capability of the device enabled researchers to calculate and specify the volume of sound intensity in certain hours of each shift, as well as its mean in each shift.

The second part of the demographic information questionnaire included items which asked the participants to provide information on their age, gender, educational level, marital status, work history, employment status, number of shifts per month, and amount of overtime per month. The third part, which was the researcher's checklist of medication errors, included 25 items that were developed based on the standards of preparing and administering medicine to the patients and recording it. In order to complete the checklist, the researcher accompanied the nurse during the preparation and administration of the medicine, and checked the items based on the nurse's performance. Finally, the number of correct cases and the number of medication errors committed by the nurse were counted. To check the validity of this instrument, first, the researcher gave it to 10 professors of the nursing school and asked them to comment on the eloquence, necessity, and relevance of each item. Next, the researcher modified the form of some of the items based on their comments, and calculated the content validity index (CVI) and content validity ratio (CVR). The CVR of the items ranged from 0.38 to 1. The standard number for 13 experts is 0.54 in the Lavshe table. Therefore, 3 items that had a CVR score in the range of 0.38 to 0.53 were removed. Finally, the items whose CVR was within the acceptable limits (between 0.54 and 1) remained. Moreover, the CVI of the items was between 0.84 and 0.92. Consequently, none of the items was removed according to the standard number of 0.79. The final checklist had 25 items.

In order to determine the reliability of the checklist, the method of agreement between evaluators was used. That is, first, two evaluators simultaneously observed the medication actions of three nurses (two times for each nurse). Next, the coefficient of agreement between evaluators for these observations was calculated. The results showed that this coefficient was equal to 92.5 %.

Ethical consideration:

Permission to conduct the study was obtained from the Ethics Committee of Kashan University of Medical Sciences (IR.KAUMS.NUHEPM.REC.1399.089). After obtaining the permission, the researchers asked the hospital and ward officials to provide the nurses who worked in the relevant wards with information about the objectives of the study and to apprise them of the fact that the study examined and recorded their behavior in the field of medicinal measures. Next, consent for the study was obtained from the research units. Moreover, they were informed that participation in the study was completely voluntary and that they could withdraw from the study whenever they wanted. Lastly, the researcher assured the participants that the collected information was completely confidential.

Data analysis:

Data were entered into SPSS16 software (SPSS Inc., Chicago, IL, USA). Descriptive statistics such as central and dispersion indices, Kruskal-Wallis, Mann-Whitney, and Spearman's correlation coefficient were used. Poisson analysis was also used to control confounding factors. The significance level was considered to be less than 0.05.

Results

The results showed that the mean sound equivalent level in medical ward 4 was 58.94 ± 1.88. This level was the highest mean compared to the other wards and showed a statistically significant difference (p = 0.001). That is, the results of the Mann-Whitney post hoc test with Bonferroni correction showed that the differences between the cardio-respiratory ward and General surgery ward and Neurosurgery ward were statistically significant (p = 0.0001). Regarding the mean of medication errors, the results of the study showed that the Neurosurgery ward had the highest number of errors with a mean of 6.17 ± 3.01 that indicated a statistically significant difference between the wards (p = 0.001, Table 1).

Table 1. The mean sound equivalent level and medication errors by ward

Wards	Sound equivalent level (L_{eq}) Mean ± Sd	*p* value*	Medication error (Number per nurse) Mean ± Sd	*p* value*
Gastrointestinal	57.92 ± 2.54	0.001	3.07 ± 2.34	0.001
Cardio-respiratory	58.94 ± 1.88		2.77 ± 1.98	
General surgery	56.94 ± 2.71		5.91 ± 4.19	
Neurosurgery	57.24 ± 2.27		6.17 ± 3.01	
Total	57.82 ± 2.45	-	4.37 ± 3.46	-

* Mann-Whitney test

The results of Spearman's correlation coefficients regarding the relationships between the mean sound equivalent level and the number of medication errors indicated that there was no significant difference in a number of wards, including the gastrointestinal ward (r = 0.72, p = 0.05), medical ward 4 (r = 0.55, p = 0.07), general surgery ward (r = 0.21, p = 0.18), and Neurosurgery ward (r = 0.66, p = 0.06). Moreover, there was no significant relationship among the morning shift (r = 0.19, p = 0.11), evening shift (r = 0.54, p = 0.07), and night shift (r = 0.12, p = 0.28). In regard to the relationship between the mean sound equivalent level by the day of the week and shift, the results of the Kruskal-Wallis test did not show a statistically significant relationship ($p < 0.05$, Table 2).

Table 2. The mean sound equivalent level on weekdays by shift

Days*	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	*p* value**
Morning (shift)	59.77 (1.96)	59.08 (2.54)	60.58 (2.36)	60.02 (2.49)	59.77 (3.54)	-	59.77(-)	0.836
Evening (shift)	59.67 (-)	57.65 (2.42)	57.50 (3.53)	58.38 (2.62)	58.59 (3)	57.5 (2.31)	58.46(-)	0.411
Night (shift)	54.8 (-)	-	54.08 (4.31)	57.31 (5.20)	30.57 (2.66)	57.08 (4.38)	57.08 (1.5)	0.445

* Median (Interquartile range);** Kruskal-Wallis test

The results of the Poisson model showed that entering the mean sound equivalent level without controlling the other variables in the model resulted in a significant effect of the mean sound equivalent level variable on the number of medication errors (p = 0.001). In model two, Hosmer's method was used to select significant variables. In this manner, each of the variables was entered into the model individually, and the other variables were added to the model ($p <$ 0.25). After entering the significant variables, the researcher removed the variables that were not significant step by step from the model. The mean sound equivalent level variable was not a significant variable. Nonetheless, it remained in the model since it was the primary variable. In model two, the ward variable was significant ($p > 0.05$), and according to the coefficients, the mean number of medication errors in the neurosurgery ward ($e^{0.7} = 2.01$) was equal to the mean number of these errors in the gastrointestinal ward. Moreover, in the general surgery ward, $e^{0.68} =$ 1.97, which was equal to the gastrointestinal ward. Furthermore, in this model, the marriage variable was significant and the number of errors committed by unmarried people ($e^{0.22} = 1.25$) was 1.25 times more than the number of errors that were committed by married people (Table 3).

Table 3. The relationship between mean sound equivalent level and the number of medication errors according to demographic characteristics

Model *	Parameter		Coefficient	Standard deviation	RR exp (B)	*p* value
1	Mean sound equivalent level (L_{eq})		-0.05	0.01	0.951	0.001
2	Width from the origin		0.16	0.89	1.173	0.85
	Mean sound equivalent level (L_{eq})		0.002	0.014	1.002	0.89
	Ward	Neurosurgery	0.70	0.09	2.014	0.001
		General surgery	0.68	0.10	1,973	0.001
		Cardio-respiratory	-0.01	0.11	0.990	0.378
		Gastrointestinal	-	-	1	-
	Marital status	Unmarried	-0.22	0.09	0.802	0.014
		Married	-	-	1	-
	Age		0.03	0.01	1.030	0.002
	Weekday		0.04	0.02	1.041	0.035

*Poisson model

Discussion

The results of the present study showed that there was no statistically significant relationship between the mean sound equivalent level and the number of medication errors. Likewise, the study of Pereira et al. in Brazil showed that there was no significant relationship between mean sound equivalent level and nursing errors in different hospital wards (17). Nonetheless, the results of the Kabule study that was conducted by Kaboodmehri et al. in Iran showed that there was a statistically significant relationship between medication errors and high noise levels (15). Similarly, the results of the study by Mahmoud et al. showed that mean sound equivalent level affected the occurrence of medication errors (20). The results of the study conducted by Watson et al. in Ohio showed that long-term exposure to noise pollution led to noise-induced stress, which was a predictor of job burnout and increased medical and nursing errors of nurses and doctors in the special care wards (21).

In the present study, it can be stated that the mean sound equivalent level was lower than the mean level in similar studies (as shown in Table 1) and the mean level provided by the World Health Organization. The sound, which is less than 30 dB during the day and 30 to 40 dB during the night (22), is closer to the aforementioned levels and therefore it did not have significant effects on the nurses' performance in administering medication to the patients. Regarding the low level of sound in this study, it can be stated that the present study was conducted during the COVID-19 crisis, leading to fewer visitors and companions for the patients. Therefore, the mean sound equivalent level in the wards was lower and this problem could not affect the occurrence of medication errors. According to the results of the studies, one of the causes of noise pollution in hospital wards is the presence of companions visiting patients (4). Moreover, it can be argued that the nurses may become accustomed to this level of noise, which they hear every day of the week, and are able to ignore it while providing medical care to the patients.

The difference between the results of the previous studies and the results of the present study may stem from the differences in the investigated wards. More specifically, in this study, the internal and surgical wards were investigated, while the aforementioned studies examined the special care wards.

Another result of the study was the existence of a high level of noise in medical wards compared to the surgical wards. The study conducted by Fillary et al. in England showed that the noise pollution level in the medical wards of the hospital, especially during the night, was higher than the other wards of the hospital (21). The results of the present study are consistent with the results of the aforementioned study. Nonetheless, the results of the study carried out by McLaren et al. showed that the highest mean sound equivalent level in the hospital was related to the surgical ward (23). It can be stated that patients hospitalized in the medical wards had more serious problems and had a longer stay in the ward. Moreover, they were more frequently visited and underwent procedures during the day. All of these factors increased the amount of sound in these areas. In this regard, Sheu et al. carried out a study in Taiwan and reported that there was a significant difference between the occurrence of errors, additional noises, and the type of wards. They found a larger number of errors and more excessive noises in the internal and surgical wards. Nonetheless, there were fewer errors and less noise in the women's ward. They stated that more diverse drugs were used in the internal and surgical wards and this issue increased the probability of medication errors compared to other wards (24). The difference between the results of McLaren et al.'s study (23) and this study may stem from the difference in the research environments of these studies, as their research environment was culturally different from the research environment in our country.

The results of the present study showed that there was not a significant difference between the mean sound equivalent level and the medication errors in terms of days of the week. This means that the sound volume did not affect the number of errors on all days of the week. In this regard, Qutub et al. conducted a study in Saudi Arabia and reported that there was not a statistically significant difference between the mean sound equivalent level on weekdays in the intensive care unit and between the mean sound equivalent level and nursing errors on different shifts and days. There was not a statistically significant difference between different weeks (24). Notwithstanding, the results of another study showed that the mean sound equivalent level and subsequent nursing errors were more frequent on the first days of the week in comparison with the weekend (25). In this regard, it can be stated that the examined environment in the present study was a teaching hospital with a government tariff, and patient referrals were ongoing every day of the week. On the other hand, the results indicated that the mean sound equivalent level was the same on all days of the week. Therefore, this equal level of sound did not affect the occurrence of medication errors. Another difference between the results of the present study and other studies was the difference in their environments and operational conditions of hospitals, which had an impact on the results. Furthermore, it seems that a number of factors including, the number of personnel members and customer reviews on that day and time, the physical space of wards, traffic, and the selection and maintenance of ward supplies, can be effective in increasing the mean sound equivalent level and nursing errors.

The results of the present study showed that there was a significant relationship between the mean sound equivalent level and the number of medication errors with age. That is, an increase in the mean sound equivalent level and age was accompanied by an increase in medication errors. Nonetheless, the results of a study that was conducted in Ahvaz showed that most medication errors were committed by the nurses who ranged in age from 28 to 32 (26).

The present study showed that noise pollution increased medication errors more among the unmarried individuals compared to married individuals. Notwithstanding, the results of the studies that were carried out by Soori et al. and Hayes et al. showed that there was no statistically significant difference between marital status and medication errors (27, 28). The difference between the results of these studies and the present study may stem from the fact that the variable effect of noise pollution was not investigated in the above-mentioned two studies. It can be stated that unmarried people had more free time, worked more shifts, and worked over time. These factors resulted in their fatigue, decreased their level of accuracy, and increased their medication errors (29). Furthermore, the mood disorders in unmarried people's which stem from noise pollution, may increase their errors. In this regard, the results of the relevant studies have indicated that noise pollution causes more sensory disturbances in unmarried people (30).

Conclusion

The results of the present study showed that there was no relationship between the mean sound equivalent level and the number of medication errors that were committed by the nurses of Shahid Beheshti Hospital in Kashan. Nonetheless, other factors such as the type of ward, age, and marital status were influential factors in their errors. Therefore, it is necessary to take certain measures to improve the conditions of the nurses' working environment, especially for the older people, and the unmarried people who work in wards with higher mean sound equivalent levels, in order to reduce the number of their medication errors that may endanger the patients' lives.

One of the limitations of the present study was its environment since it was conducted in a hospital and the internal and surgical wards. Therefore, the results of the study may not be generalizable to other centers. Considering this issue, it is recommended that the researchers conduct larger multicenter studies in all of the hospital wards to generalize their results to other centers. Moreover, another limitation of this study was its time period since it was conducted during the coronavirus crisis. Consequently, it is necessary to conduct a study in non-coronavirus conditions to check the effects of the presence of more companions in the ward on the number of errors.

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Conflict of interest

The authors have no conflict of interest in this study.

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Data availability

The raw data supporting the conclusions of this article are available from the authors upon reasonable request.

Ethical statement

This research was conducted in accordance with ethical principles and received the ethics code IR.KAUMS.NUHEPM.REC.1399.089 from the ethics committee of Kashan University of Medical Sciences.

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