EHT Environmental Health and Toxicology

Open Access

Volume: 29, Article ID: e2014006, 6 pages
http://dx.doi.org/10.5620/eht.2014.29.e2014006

• Original Article

eISSN: 2233-6567

Noise in hospital rooms and sleep disturbance in hospitalized medical patients

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Objectives Hospitalized patients are vulnerable to sleep disturbances because of environmental stresses including noise. While most previous studies on hospital noise and sleep have been performed for medical machines in intensive care units, there is a limited data for patients hospitalized in medical wardrooms. The purpose of present study was to measure noise level of medical wardrooms, identify patient-perceived sources of noise, and to examine the association between noise levels and sleep disturbances in hospitalized patients.

Methods Noise dosimeters were used to measure noise level in 29 inpatient wardrooms at a university hospital. Sleep pattern and disturbance were assessed in 103 hospitalized patients, using the Pittsburgh Sleep Quality Index (PSQI) and Leeds Sleep Evaluation Questionnaire.

Results The mean equivalent continuous noise level for 24 hours was 63.5 decibel A (dBA), which was far higher than 30 dBA recommended by the World Health Organization for hospital wardrooms. Other patients sharing a room were perceived as the most common source of noise by the patients, which was usually preventable. Of the patients in the study, 86% had bad sleep as assessed by the PSQI. The sleep disturbance was significantly correlated with increasing noise levels in a dose response manner.

Conclusions Systemic organizational interventions are needed to keep wardrooms private and quiet to reduce sleep disturbance.

Keywords Hospital noise, Medical wardrooms, Perceived noise, Quality assurance, Sleep disturbance

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Received: May 31, 2014
Accepted: July 25, 2014
Published online: August 18, 2014

This article is available from: http://e-eht.org/

Introduction

Sleep is a physiologic phenomenon that is essential for maintaining health, relieving stress and anxiety, and helping the body recover. Sleep can be disturbed by sudden environmental changes [1]. Sleep disturbance in hospitalized patients has been studied, and minimizing disruption of sleep cycle is currently considered as a part of patient care. Patients have been reported to experience improved or worsened neurological and cardiovascular problems depending on the environmental stress from being hospitalized [2]. Sleep quality of hospitalized patients has been suggested to be considered as a part of routine medical evaluation, similar to routine vital signs checks [3].

Noise in hospital rooms was reported to be the most significant factor interfering with patient sleep [4-6]. Furthermore, higher ambient noise levels in hospitals were found to correlate with longer hospitalizations [7].

While most studies on hospital noise in association with sleep

disturbance has focused on machine noises in intensive care units [8,9], such investigations have been limited for patients in general hospital wardroom [2]. The purpose of this study was to measure the noise level of general medical hospital rooms for 24 hours, identify noise sources, assess sleep quality of inpatients, and examine the association between noise levels and sleep disturbance in these patients.

Materials and Methods

Study Subjects

The study enrolled patients who were hospitalized at an internal medicine department at a university hospital. A total of 103 patients in 29 wardrooms participated in the study. Patients were excluded from the study if they had been hospitalized less than three days to exclude possible effects of acute environmental changes and physical discomfort on patients' sleep disturbance, or if they had hearing problems, dementia, coma, severe psychiatric disorder, and communication problems. Data was collected for patient age and gender, number of roommates, duration of hospitalization, and patient-perceived sources of noise, by administering a questionnaire to participating patients. All analyses were performed after excluding any personal identifiers. This study was reviewed and approved by the institutional review board at the Dankook University Hospital. Written informed consent was obtained from all participants.

Measuring the Noise Level of Rooms in the Hospital

A total of 29 rooms were measured for ambient noise level using 13 dosimeters (Spark® 703; Larson Davis 703 series, PCB Group Co., Provo, UT, USA) according to the guidelines from the Ministry of Environment, Korea [10]; the noise-meters were placed at ear level of patients, and were left to measure noise levels for 24 hours. Two noise level metrics, the equivalent continuous noise level (L_{eq}) and the maximum noise level (L_{max}), were used for all analyses.

Sleep Disturbance Assessment

In order to assess sleep quality of participating patients, the Korean version of Pittsburgh Sleep Quality Index (PSQI) and the Leeds Sleep Evaluation Questionnaire (LSEQ) were used. The PSQI is a self-administered questionnaire with 19 questions about overall sleep pattern, and is scored from 0 to 21 points [11] with higher scores indicating worse quality of sleep. The cut-off PSQI score of 5 was used to define sleep disturbance in this study. PSQI was originally designed to evaluate a person's sleep for the month leading up to the survey. Since patients in this study were admitted for less than a month (average of 13 days), we modified the PSQI questionnaire to assess "sleep quality during the hospitalization", rather than during the past one month.

The LSEQ was used to compare sleep patterns before and after hospitalization; it has 10 questions on sleep latency, quality of sleep, awakening from sleep, and behavior following wakefulness. Each question is scored from 0 to 10 [12], with higher scores reflecting improved sleep quality.

Confounding Factors

The severity of a patient's disease (levels 1, 2, and 3 in order of severity) was evaluated according to the guidelines for hospital evaluation program 2006 [13], which consisted of 12 items, i.e., hygiene, self-urination/defecation, and nutritional status of patients. According to the university hospital drug formulary of 2009 [14], a list of sleep interfering drugs was generated as well as those that cause drowsiness and/or insomnia. Subsequently, the medical records of each patient were evaluated for these medications.

Statistical Analysis

The difference of noise levels among different types of rooms and difference in sleep disturbance according to the general characteristics of the patients were tested using *t*-test or analysis of variance. Multiple linear regression analyses were performed to examine the relationship between noise level and sleep disturbance, after adjusting for age, gender, severity of disease, medication of sleep interfering drug, and type of room. Estimation of lower limit of noise level required for no sleep disturbance was calculated by a simple regression model. All analyses were performed using SPSS version 14.0 (SPSS Inc., Chicago, IL, USA) with a two tailed significance level of 0.05.

Results

General Characteristics of Patients

Males accounted for 59 (57.2%) of the patients. The average age of the participating patients was 60 years of age, and 85% were between 40 and 70. Two patients used a ward room without other patients (1 bed); one patient shared a room with another patient (2 beds); 37 shared room with three other patients (12 rooms with 4 beds each); and, 63 patients shared room with 5 other patients (14 rooms with 6 beds each). The most com-

mon disease severity was level 2 (76.7%). More than half of patients (66%) took sleep-interfering drugs (Table 1).

Noise Level of the Hospital Rooms

The median L_{eq} noise was 64.2 and 60.9 decibel A (dBA) during the day and night, respectively, and 61.2 and 67.3 dBA in 4-bed and 6-bed rooms, respectively. The median L_{max} was also higher during day (86.1 dBA) than during night (80.4 dBA), but higher in 4-bedrooms (87.4 dBA) than in 6-bedrooms (85.3 dBA). The differences between noise level during day and night was statistically significant while that between 4-beds and 6-bed rooms was not (Table 2).

Table 1. Characteristics of study patients hospitalized in internal medicine department

Variables		No. of patients (n=103)
Age, mean (SD)	60.0 (14.8)	
Gender	Male	59 (57.2)
	Female	44 (42.8)
Severity of disease[a]	1 (least severe)	18 (17.5)
	2	79 (76.7)
	3 (most severe)	6 (5.8)
Medication of sleep interfering drug[b]	No	35 (34.0)
	Yes	68 (66.0)
Type of hospital rooms (bed)	1 (n=2)	2 (1.9)
	2 (n=1)	1 (1.0)
	4 (n=12)	37 (35.9)
	6 (n=14)	63 (61.2)

Values are presented as number (%).
[a]From Ministry of Health and Welfare. Guidelines for hospital evaluation program 2006 [13].
[b]From Dankook University Hospital. 2009 drug formulary [14].

Sleep Disturbance of the Patients

When compared to before hospitalization, getting to sleep, quality of sleep, awakening from sleep, and behavior following wakefulness were respectively worse in 44 (42.7%), 57 (55.3%), 46 (44.7%), and 52 (50.5%) of patients, as assessed by the LSEQ.

Of the 103 patients, 89 (86%) had disturbed sleep based on the PSQI score (5 or more). The PSQI scores were higher in female patients than in male ($p=0.06$) patients, and was higher in patients with higher disease severity than those with lower disease severity ($p=0.04$). The LSEQ-measure of sleep quality was better for patients who did not take sleep-interfering medicine than for those that did ($p=0.08$) (Table 3). Patient age and room type did not affect sleep disturbance patterns from the PSQI and LSEQ evaluations.

Association between Noise Level and Sleep Disturbance in Patients

Sleep disturbance scores significantly increased according to increases in the mean of the equivalent noise level in day and night even after adjustment for several potential confounders (age, gender, severity of patients' disease, medication of sleep interfering drug and type of room) ($\beta=0.20$; 95% confidence interval [CI] = 0.09-0.53 for day, $\beta=0.12$; 95% CI = 0.07-0.36 for night). The maximum noise level, however, was not associated with

Table 2. Noise level of hospital rooms in internal medicine department according to time windows (unit; dBA)

	All (n=29)	*p*-value[a]	Type of hospital rooms				*p*-value[b]
			For 1 bed (n=2)	For 2 beds (n=1)	For 4 beds (n=12)	For 6 beds (n=14)	
24 Hours							
L_{eq} mean (Med)	63.6 (64.4)	<0.05	64.5 (64.5)	70.7	62.7 (61.2)	63.8 (67.3)	0.23
(Min, Max)	(55.7, 70.7)		(60.3, 68.7)	-	(55.7, 68.3)	(57.0, 69.1)	
L_{max} mean (Med)	86.6 (86.5)	<0.05	84.2 (84.2)	84	86.8 (87.4)	86.6 (85.3)	0.80
(Min, Max)	(79,7, 99.9)		(79.7, 88.7)		(80.0, 93.6)	(80.0, 99.9)	
Day (07 am - 07 pm)							
L_{eq} mean (Med)	64.4 (64.2)		64.3 (64.7)	70.7	63.4 (60.9)	64.8 (67.8)	0.07
(Min, Max)	(57.9, 70.7)		(60.2, 68.4)	-	(57.9, 68.2)	(58.1, 69.4)	
L_{max} mean (Med)	86.1 (86.1)		84.2 (78.8)	84	86.3 (83.0)	86.1 (80.4)	0.80
(Min, Max)	(79.7, 99.9)		(79.7, 88.7)		(80.0, 93.6)	(80.0. 99.9)	
Night (07 pm - 07 am)							
L_{eq} mean (Med)	62.2 (60.9)		64.7 (64.3)	70.7	61.2 (63.2)	62.6 (66.9)	0.27
(Min, Max)	(50.9, 70.7)		(60.4, 68.9)	-	(50.9, 68.6)	(53.6, 69.3)	
L_{max} mean (Med)	81.5 (80.4)		78.6 (84.2)	76.9	81.4 (86.9)	81.7 (86.1)	0.84
(Min, Max)	(71.0, 98.6)		(77.9, 79.6)		(71.0, 87.4)	(73.5, 98.6)	

All *p*-values were calculated by comparing mean noise level using *t*-test.
L_{eq}, Equivalent continuous level of noise; L_{max}, Maximum level of noise; Min, minimum; Med, median; Max, maximum.
[a]Between day and night time in all rooms.
[b]Between rooms with 4 and 6 beds.

Table 3. Sleep disturbance pattern according to hospitalized patients' characteristics in internal medicine department

		n	Sleep disturbance score				
			PSQI	LSEQ			
				Getting to sleep	Quality of sleep	Awakening of sleep	Behavior of following wakefulness
Gender	Male	59	8.03 (3.52)	4.45 (1.64)	4.18 (1.53)	4.44 (1.50)	4.29 (1.52)
	Female	44	9.34 (3.42)	4.93 (1.56)	3.84 (1.71)	4.33 (1.44)	3.96 (1.67)
	p-value		0.06	0.91	0.52	0.99	0.30
Age (yr)	17-53	35	8.49 (3.43)	4.19 (1.74)	3.82 (1.69)	4.33 (1.56)	3.76 (1.67)
	54-70	34	9.00 (3.65)	4.54 (1.66)	3.71 (1.71)	4.23 (1.49)	4.11 (1.56)
	71-82	34	8.29 (3.56)	5.29 (1.36)	4.64 (1.39)	4.64 (1.37)	4.63 (1.49)
	p-value		0.70	0.27	0.18	0.69	0.27
Severity of patients' disease[a]	Less severe	18	7.22 (2.86)	5.08 (1.88)	3.80 (1.99)	5.32 (1.34)	4.99 (1.58)
	More severe	85	8.88 (3.60)	4.56 (1.55)	4.08 (1.53)	4.22 (1.48)	3.98 (1.57)
	p-value		0.04	0.17	0.14	0.62	0.30
Medication of sleep interfering drug	Yes	68	8.62 (3.75)	4.35 (1.65)	3.85 (1.60)	4.39 (1.43)	3.89 (1.59)
	No	35	8.54 (3.08)	5.29 (1.47)	4.41 (1.63)	4.40 (1.56)	4.69 (1.53)
	p-value		0.92	0.57	0.08	0.15	0.57
Type of rooms (bed)	1	2	7.50 (3.54)	4.58 (1.82)	4.95 (1.63)	4.81 (1.16)	3.00 (1.77)
	2	1	8.00	6.00	3.00	7.00	7.00
	4	37	8.65 (3.15)	4.80 (1.59)	4.09 (1.77)	4.61 (1.36)	4.61 (1.50)
	6	63	8.60 (3.80)	4.55 (1.63)	4.03 (1.52)	4.39 (1.54)	4.14 (1.61)
	p-value[b]		0.97	0.91	0.62	0.41	0.18

Values are presented as mean (standard deviation).
Sleep disturbance assessed by Pittsburgh Sleep Quality Index (PSQI) and Leeds Sleep Evaluation Questionnaire (LSEQ).
All *p*-values were calculated using *t*-test or ANOVA.
[a]Severity of patients' disease: less severe (score 1 or 2), more severe (score 3).
[b]Comparison of sleep disturbance scores in patients in room for 4 beds with those in room for 6 beds.

Table 4. Association between noise level of room in internal medicine department and sleep disturbance of hospitalized patients

Noise in rooms	PSQI score					
	Unadjusted			Adjusted[a]		
	β	SE	95% CI	β	SE	95% CI
Equivalent noise level (dBA)						
24 Hours	0.22	0.08	0.07, 0.37*	0.20	0.07	0.05, 0.42*
Day	0.24	0.09	0.06, 0.42*	0.20	0.09	0.09, 0.53*
Night	0.13	0.06	0.01, 0.24*	0.12	0.06	0.07, 0.36*
Maximum noise level (dBA)						
24 Hours	0.16	0.07	0.02, 0.30*	0.13	0.07	0.01, 0.32*
Day	0.13	0.08	-0.02, 0.23	0.10	0.07	-0.01, 0.48
Night	0.11	0.06	-0.01, 0.24	0.12	0.06	-0.01, 0.21

Sleep disturbance assessed by the Pittsburgh Sleep Quality Index (PSQI).
SE, standard error; CI, confidence interval.
[a]Parameter estimated using multiple linear regression model adjusted for age, gender, severity of patients' disease, medication of sleep interfering drug, and type of room.
*$p<0.05$.

sleep disturbance during day or night (Table 4). Sleep disturbance measured by the LSEQ did not show a significant association with ambient noise level of hospital rooms (data not shown).

The Noise Level Required for No Sleep Disturbance in Hospitalized Patients

The estimated limits of L_{eq} (L_{max}) required for no sleep disturbance (PSQI score less than 5) were calculated to be 49.3 (59.3 dBA) at daytime, 34.2 (50.5 dBA) at night time, on linear regression model.

Perceived Sources of Noise

The most common sleep disturbed patient-perceived sources of noise was noise caused by other patients' caregivers and visi-

Table 5. Perceived sources of noise by hospitalized patients in internal medicine department

Perceived sources of noise[a]	All	Patients not disturbed sleep[b] (n=14)	Patients disturbed sleep[b] (n=89)
Other patients' caregivers or visitors	22 (21.4)	1 (7.1)	21 (23.6)
Other patients' snoring	18 (17.5)	0 (0.0)	18 (20.2)
Toilet flushing	16 (15.5)	3 (21.4)	13 (14.6)
Cartwheel sound	14 (13.6)	1 (7.1)	13 (14.6)
Telephone and TV	13 (12.6)	0 (0.0)	13 (14.6)
Personal medical device	11 (10.7)	2 (14.3)	9 (10.1)
Procedure by medical staffs	10 (9.7)	0 (0.0)	10 (11.2)

Values are presented as number (%).
[a]Patients could respond to multiple sources.
[b]Sleep disturbance assessed by the Pittsburgh Sleep Quality Index.

tors (23.6%), followed by noise caused by other patients such as snoring or groaning , toilet flushing, medication/food carts and phone or TV sound , personal medical staff, and medical devices (Table 5).

Discussion

The results of this study indicated that the equivalent (maximum) noise level of wardrooms in the university hospital to be 63.6 dBA (86.6 dBA), which was higher than the recommended level by the domestic policies in South Korea [10] as well as by the World Health Organization (WHO) [15]. Among various sources, noise from other patients or caregivers sharing the rooms was the most common type of disturbance. Of the study participants, 86% experienced sleep disturbance that was significantly associated with noise levels in hospital rooms, after adjusting for several confounding factors.

An interesting finding was that patient-perceived sources of noise in medical wardrooms were different from those reported for intensive care units (noises of human activity versus machines). Although there were no statistically significant differences in noise level between types of room, the L_{max} at night was lower in 1- or 2-bed rooms than for 4- or 6-bed rooms. In addition, PSQI scores were higher among patients in 4- or 6-bed rooms than those in 1- or 2-bed rooms. Along with these findings, "human" sources of noise (caregivers, visitors or snoring roommates) were reported by the sleep disturbed patients as the main sources of noise in medical wardrooms rather than structural sources in hospital buildings. These types of noise sources are usually preventable [16] by an appropriate hospital environmental management. Furthermore, even in the medical wardroom, noise was associated with sleep disturbances, which suggests that a different interventional approach is necessary to reduce sleep disturbance in medical wardrooms.

In terms of sleep disturbance, noise levels have been reported from 50 to 75 dBA with the highest night peak reaching 103 dBA in intensive care units [9] and 48 dBA in L_{eq} and 80.3 dBA in L_{max} in medical inpatient rooms [16]. Noise levels measured in our study were similar (or a bit higher) with these previous findings. The WHO's recommended noise levels are 30 dBA inside hospital wardrooms for sleep disturbance prevention [15], and 50 dBA for day and 40 dBA for night have been recommended by the Korea Ministry of Environment [10]. These recommended values are much lower than those noise levels measured in present study. In addition, the limits of noise level for no sleep disturbance were estimated to be 49.3 dBA at day and 34.24 dBA at night in the present study, which are similar to existing recommendations, indicating the validity of this study.

In South Korea, most hospitals have five to six patients in one room, and therefore are less quiet and associated with more discomfort with regards to sleeping [17]. About 80% of hospitalized patients reported that they were frequently woken up during sleep and did not feel that they were refreshed after sleep. More than half complained that the total amount of sleep decreased after hospitalization in a medical department [18]. Moreover, older patients were prescribed more neuroleptic drugs, which suggests that they need more advanced care with regard to sleeping [19].

Noise was reported to be the most common factor interfering with sleep among inpatients [2,4,5]. Higher levels of noise are associated with increased use of anesthetic drugs [20], which can lengthen the duration of hospitalization [7]. Noise increases production of angiotensin II in the blood and can increase the risk of a stroke [21], increases cholesterol and triglyceride levels and the risk of diabetes [22], triggers elevation of blood pressure and pulse rate, and increases muscle tension, intracranial pressure, skin electrical resistance, sweating, contraction of peripheral blood vessels and hearing impairment [23]. Therefore, noise control is important for patient satisfaction and health outcomes in the hospital setting.

The present study has some limitations. The small sample size limits statistical power of the analyses. The finding that sleep disturbance measured by the LSEQ did not show a significant association with ambient noise level of hospital rooms in the

present study might be due to lack of statistical power, or the different sensitivity and validity compared to the PSQI in measurement of sleep disturbance. Second, because of the limited functions of noise dosimeters, we could not analyze the detailed noise characteristics, i.e., duration, impulsiveness, and tonal quality and etc., in relation with the sleep quality, which might provide some insights on the biophysical mechanism of noise-induced sleep. Third, patients' mood state, i.e., stress, anxiety and depression, affects sleep quality and may play as a confounding factor in association between noise and sleep disturbance in medical patients. However, such information was not available in the present study.

The noise level in internal medicine ward rooms at a university hospital was demonstrated to be higher than recommended levels. Increasing levels of noise were associated with higher rates of sleep disturbance in hospitalized patients. The main sources of patient-perceived noise were other patients sharing the same room. The hospital management on human sources of noise (restricting visiting time and duration and decreasing number of beds in a room) are needed.

Conflict of Interest

The authors have no conflicts of interest with material presented in this paper.

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