

## Noise Pollution in Mosul Medical City Center Teaching Hospitals

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### ABSTRACT

**Context:** High levels of noise in hospitals may interfere with patient care services, the doctor-patient relationship and medical education activities.

**Aim:** To measure the noise level and to determine the time-place patterns at Mosul Medical City Center Teaching Hospitals.

**Materials and methods:** Sound levels of different places inside the stated hospitals were recorded, using a Digital Sound Level Meter. A total of 80 readings were taken at different locations of hospitals. The time for each measurement was 5 minutes, repeated for three times in each location, and then the average reading was recorded. Three noise parameters were recorded in every measurement (in dBA): equivalent noise level (Leq), maximum noise level ( $L_{max}$ ) and minimum noise level ( $L_{min}$ ). Neither the staff nor the patients in the four institutions were aware of the recordings.

Indoor noise levels on weekdays (Saturday through Thursday) were compared to noise levels on weekends (Friday). Outdoor noise levels were measured near each hospital facet, too. Time-patterns of noise pollution were established by recordings at 08:00 a.m., 09:00 a.m., 11:00 a.m., and 02:00 p.m.

**Results:** The mean equivalent sound level was  $93.44 \pm 6.55$  dBA, including hospitals facet. The maximum equivalent sound level was observed in the casualty department ( $97.80 \pm 2.91$  dBA) and the minimum equivalent sound level was in Ibn-Sena General Teaching Hospital ( $89.16 \pm 6.83$  dBA) ( $p = 0.001$ ). During morning hours, the mean equivalent noise level ( $94.35$  dBA) was higher than the afternoon level ( $90.14$  dBA) ( $p=0.037$ ). The mean equivalent noise levels were higher on the weekdays ( $94.05$  dBA) than on the weekend ( $88.57$  dBA) ( $p = 0.002$ ).

**Conclusion:** The noise pollution in Mosul Medical City center greatly exceeded the WHO guideline level for hospitals. This study highlights the need for noise monitoring and control measures inside hospital areas.

**Keywords:** Noise pollution, hospitals, patterns.

## التلوث الضوضائي في المستشفيات التعليمية لمركز مدينة الطب في الموصل

### الخلاصة

**مقدمة:** المستوى العالي للضوضاء في المستشفيات قد يؤثر على مستوى الخدمات المقدمة للمريض، وعلاقة المريض بالطبيب وكذلك على نشاطات التعليم الطبي.

**هدف الدراسة:** تهدف الدراسة الحالية إلى قياس مستوى الضوضاء وتحديد النمط المكاني والزمني لها في المستشفيات التعليمية لمركز مدينة الطب في الموصل.

**طريقة الدراسة:** تم قياس مستوى الصوت في أماكن مختلفة داخل المستشفيات التعليمية باستخدام جهاز قياس الصوت الرقمي (Digital Sound Level Meter). حيث تم أخذ ٨٠ قراءة بهذا الجهاز في أماكن متعددة من المستشفيات. كل قراءة تستغرق ٥ دقائق حيث تمت إعادة القراءة في كل موقع ثلاث مرات ثم أخذ المعدل لها. ثلاثة مقاييس للضوضاء استخدمت في هذه الدراسة: مقياس الصوت المكافئ (Leq)، مقياس الصوت المنخفض ( $L_{min}$ )، و مقياس الصوت المرتفع ( $L_{max}$ ). وكانت وحدة القياس هي الديسي بل (dBA).

**النتائج:** ظهر أن معدل الصوت المكافئ هو  $93,44 \pm 6,55$  الديسي بل في المستشفيات التعليمية بما فيها واجهة المستشفيات. وأعلى مستوى صوت مكافئ لوحظ في قسم الطوارئ  $97,80 \pm 2,91$  ديسي بل وأوطئ مستوى صوت مكافئ كان في مستشفى ابن سينا التعليمي  $89,16 \pm 6,83$  ديسي بل ( $p = 0.001$ ). وأظهرت النتائج أن مستوى الصوت المكافئ للفترة الصباحية ( $94,35$  ديسي بل) كان أعلى من المستوى لفترة ما بعد الظهر ( $90,14$  ديسي بل). كما لوحظ أن مستوى الصوت المكافئ خلال أيام الدوام الأسبوعي ( $94,05$  ديسي بل) كان أعلى من ذلك المستوى ليوم الجمعة ( $88,57$  ديسي بل) ( $p = 0.002$ ).  
**الاستنتاجات:** يشكل التلوث الضوضائي في مركز المستشفيات التعليمية لمدينة الموصل الطبية مشكلة حقيقية حيث سجلت مستويات للضوضاء فاقت بكثير المستويات القياسية للصوت لمنظمة الصحة العالمية بالنسبة للمستشفيات.  
**الكلمات الدلالية:** التلوث الضوضائي، المستشفيات، الأنماط.

Noise is a sound that lacks agreeable musical quality, is noticeably unpleasant, is undesired and interferes with one's hearing. Noise pollution is annoying or harmful in an environment <sup>(1)</sup>. Noise exceeding a quiet level of 40 – 50 decibel (dBA) is known to cause emotional reactions (annoyance), disturbed sleep, delirium, elevation of blood pressure, tachycardia and is possibly linked to ischemic heart disease, presumably as a result of coronary vasoconstriction <sup>(2-5)</sup>. Exposure to noise has been shown to have a negative impact on work performance <sup>(6)</sup>.

Recent study demonstrated a significant association with sound peaks >80 dBA and arousals from sleep <sup>(7)</sup>. Moreover, it has been found that patients have sleep fragmentation, detected as transient EEG arousals, when they receive tone bursts during all stages of sleep <sup>(8)</sup>. Sleep deprivation has been demonstrated to affect task performance, general mood, and level of alertness, and can lead to increased daytime fatigue <sup>(9)</sup>. Observational studies have shown that at least one third of sleep-deprived persons have symptoms consistent with "intensive care unit psychosis" syndrome and that patients identify staff noises as the most disturbing <sup>(7-9)</sup>. A three-minute noise at 36 dBA will awaken about half of people in stage 2 sleep, but the noise level must be raised to 83 dB to awaken half of sleepers in stages 3 and 4 <sup>(3)</sup>. Older people and women are more vulnerable to the disruptive effects of noise on sleep. Since older people sleep less deeply than younger people, a 70-year-old is about twice as likely to be awakened by sound as a 20-year-old <sup>(3)</sup>.

Noise has also been implicated as a cause of hearing loss, especially in patients concomitantly receiving ototoxic drugs such as aminoglycosides <sup>(1,6)</sup>. Additionally, noise has been

implicated in contributing to critical care nurse burnout <sup>(10)</sup>.

A noise level above 70 dBA is a typical environmental stressor triggering acute and chronic increase in catecholamine levels (epinephrine and norepinephrine) from the adrenal medulla in normal persons, whereas anxious people have especially large increases in plasma and urinary hydroxycorticosteroid levels <sup>(11)</sup>.

A hospital must create a quiet, calm environment for patients by providing a physical setting conducive to recovery and an organizational culture that supports patients and families through the stresses imposed by illness, hospitalization, medical visit, healing and bereavement. To accomplish these, hospital employees must identify internal and external noise factors. Also the hospitals must measure and reduce the noise in patient's room with defined compliance levels <sup>(12)</sup>.

Environmental noise in hospitals has received attention in the medical literature. The Environmental Protection Agency recommends that noise levels in the hospital setting not exceed 45 dBA during the day and 35 dBA at night <sup>(13)</sup>. While the International Noise Council and the World Health Organization has recommended that noise levels in hospital areas should be 35-40 dBA in the daytime and 30-40 dBA in the evening <sup>(14-15)</sup>.

The aim of the present research is to measure noise levels, and to determine its time-and place-patterns in Mosul Medical City Center Teaching Hospitals (Mosul MCCTHs) and Casualty Department (CD) within the mentioned center.

## MATERIALS AND METHODS

**Administrative agreement and design:** Before starting data collection administrative and ethical agreements were obtained from Nineveh Directorate of Health. To achieve the aim of the

present study, hospital-based descriptive study design was adopted.

**Study settings:** The levels of noise measured in the following settings: Al-Jamhory, Al-Batool Maternity and Ibn-Sena General Teaching Hospitals. In addition to the CD. This department is attached to Al-Jamhory Teaching Hospital and located nearby the same hospital.

**Method of noise estimation:** Noise levels were recorded by the last author using Digital Sound Level meter (SLM) which is a hand hold instrument, (Model 2900 a product of QMEST TECHNOLOGIES (1060 Corporate Center Drive Oconomowoc, WI 53066 NSA 800-245-D779)), in dBA at different areas of the study settings and at various times. Before each measurement, standardization of the equipment was done. The time for each measurement was 5 minutes, recording was repeated for three times in each location, and then the average reading was recorded. A total of 80 readings were taken in different locations of the study settings. Three noise parameters were recorded in every measurement in dBA: equivalent noise level (Leq), maximum noise level ( $L_{max}$ ) and minimum noise level ( $L_{min}$ )<sup>(15)</sup>. In order to obtain a realistic recording of noise levels, neither the staff nor patients in the four institutions were aware of the recordings

In order to find place-pattern of noise pollution, noise levels were recorded in four places of the Mosul MCCTHs. The 1<sup>st</sup> location was hospital floors: medical, gynecological and/or surgical floors. The 2<sup>nd</sup> location was consultation units. The 3<sup>rd</sup> location was intensive care units i.e. coronary care unit (CCU), respiratory care unit (RCU), and surgical intensive care unit (SICU) and finally nurses' stations. In addition to CD rooms: medical and surgical units. In all hospitals areas, noise levels on weekdays (Saturday through Thursday) were compared to noise levels on weekends (Friday). Outdoor noise levels were also measured near each hospital facets.

In order to establish time-patterns of noise pollution, recordings were obtained at 08:00 a.m., 09:00 a.m., 11:00 a.m., and 02:00 p.m.

**Outcome measure and statistical analysis:** The main outcome measure used was noise level in

dBA. The parameter universally used in the discussion of noise pollution is Leq, the equivalent continuous noise level expressed in dBA, which is the average rate at which energy is received by the human ear during the period monitored. The other variables obtained were  $L_{max}$  and  $L_{min}$  which are the maximum and minimum noise levels recorded at each place respectively.

Data were tabulated using Minitab – version 13.2 and analyzed using simple descriptive statistics. Independent (unpaired) T- test for two means and analysis of variance for multiple means were used.  $P \leq 0.05$  were considered significant throughout data analysis.

## RESULTS

The mean Leq for all study areas was  $93.44 \pm 6.55$  dBA, including hospitals facet. **Table 1** shows the mean Leq for individual areas in the MCCTHs and CD rooms. Regarding the average level for each hospital setting, the maximum Leq was observed in the CD ( $97.80 \pm 2.91$  dBA) and the minimum Leq was in the Ibn-Sena General TH ( $89.16 \pm 6.83$  dBA) with a difference of highly significant value,  $p = 0.001$ . In respect to the different locations, the maximum mean Leq was observed in the hospital facet of Al-Jamhory TH ( $98.62 \pm 4.85$  dBA) and the minimum mean Leq was in the CCU and RCU of Ibn-Sena General TH ( $85.46 \pm 4.81$  dBA).

The minimum noise level ( $L_{min}$ ) was recorded in Ibn-Sena General TH (71.88 dBA), while the maximum noise levels ( $L_{max}$ ) was recorded in Al-Jamhory TH (113.02 dBA). When taking the different location at teaching hospitals in consideration, the hospital facet of all teaching hospitals and CD was reported the highest  $L_{min}$  and  $L_{max}$  noise levels; 74.85 dBA and 111.24 dBA, respectively (**Table 2**).

**Table 3** demonstrates time and day patterns of equivalent noise level of the present study. In all areas, the morning mean equivalent noise level (94.35 dBA) were significantly higher than the afternoon levels (90.14 dBA) ( $p = 0.037$ ). Furthermore, in all areas, the mean equivalent noise level were significantly higher on the weekdays (94.05 dBA) than on the weekend (88.57 dBA) ( $p = 0.002$ ).

Table 1. Mean equivalent noise levels in the five locations of the present study in dBA with standard deviation.

Areas	Study settings				P-value**
	Al-Jamhory TH n = 22 *	Ibn-Sena General TH n = 25	Al-Batool Maternity TH n = 19	Casualty Department n = 14	
<b>Average level</b>	<b>96.66 ± 5.91</b>	<b>89.16 ± 6.83</b>	<b>93.90 ± 4.17</b>	<b>97.80 ± 2.91</b>	<b>0.001</b>
Hospital floor	91.84 ± 5.53	85.65 ± 5.12	90.75 ± 5.87	89.55 ± 5.82	0.063
Consultation unit	94.68 ± 6.88	90.26 ± 6.11	91.22 ± 6.01	----	0.087
Intensive care units	90.43 ± 5.21	85.46 ± 4.81	----	----	0.061
Nurses' stations	97.48 ± 5.99	89.48 ± 5.93	89.48 ± 5.93	99.18 ± 5.68	0.032
Hospital facet	98.62 ± 4.85	92.62 ± 4.85	94.62 ± 4.85	97.82 ± 5.67	0.004

\* n: number of recording in each TH. \*\* ANOVA test was used.

Table 2. The mean minimum ( $L_{min}$ ) and maximum ( $L_{max}$ ) noise levels in the study settings in dBA.

Areas	Al-Jamhory TH		Ibn-Sena General TH		Al-Batool Maternity TH		Casualty Department	
	$L_{min}$	$L_{max}$	$L_{min}$	$L_{max}$	$L_{min}$	$L_{max}$	$L_{min}$	$L_{max}$
<b>Average level</b>	<b>73.80</b>	<b>113.02</b>	<b>71.88</b>	<b>97.12</b>	<b>75.53</b>	<b>111.44</b>	<b>74.52</b>	<b>110.20</b>
Hospital floor	72.81	109.89	71.67	97.65	74.59	110.07	74.76	106.26
Consultation unit	72.96	113.89	72.12	97.89	75.69	109.13	----	----
Intensive care units	70.85	100.11	68.35	89.22	----	----	----	----
Nurses' stations	73.98	112.32	71.93	96.42	74.56	110.58	74.68	109.08
Hospital facet	74.85	114.42	72.08	99.11	75.87	112.40	74.89	111.24

Table 3. Time-pattern of the mean equivalent noise level in dBA for the study setting.

Time pattern	Al-Jamhory TH	Ibn-Sena General TH	Al-Batool Maternity TH	Casualty Department	Total	P-value*
Morning	97.36	90.16	94.27	98.84	94.35	0.037
Afternoon	90.31	86.32	90.89	92.81	90.14	
Weekdays	97.39	90.68	94.57	98.89	94.05	0.002
Weekend	88.45	84.31	89.46	93.87	88.57	

\* Independent t-test for two means was used.

## DISCUSSION

Generally speaking, a quiet hospital environment is in the range of 40 to 50 dBA, an intermediate environment would be at approximately 50 to 60 dBA, and a noisy environment would fall in the range of 60 to 75 dBA<sup>(12)</sup>. The decibel scale is a linear scale that reflects logarithmic increases in sound pressures, and therefore small numerical increases represent huge differences in sound. Ambient noise at most modern hospitals fall into the 50-to-70 dBA range, with occasional eruptions well above this level. The average nighttime noise level of 67 dBA measured in several acute care admission and general medical wards represents a large excess from the recommended level of 35 dBA<sup>(15)</sup>.

The results of this study revealed that excessive environmental noise was present in different stations in Mosul MCCTHs. The mean equivalent noise level found in this study was higher ( $93.44 \pm 6.55$  dBA) than noise levels found in other health care settings<sup>(12, 16-20)</sup>, where Allaouchich et al.<sup>(16)</sup> in France during 2002, did noise measurement in post anesthesia care unit of Lyon hospital and found average equivalent noise level was 67.1 dBA. Also McLaren and Maxwell-Armstrong<sup>(20)</sup> in 2008, found a mean Leq noise level of 73.5 dBA in five surgical wards at Queen's Medical Center, Nottingham-UK.

Study of noise pollution in Jeddah hospitals was conducted by Noweir and Al-Jiffry<sup>(21)</sup> on a sample of 6 hospitals during 1991; authors recorded that

the levels of noise in clinics, patient rooms, offices, waiting areas and corridors significantly exceeded the recommended standard. Another study carried out by Juang *et al.* in 2007 to assess noise level in three hospitals; one regional hospital in the central part of Taiwan and two regional hospitals in the southern part of Taiwan; showed a lower figures than that of the present study (50.3 - 68.1 dBA)<sup>(22)</sup>. In the current study the highest equivalent noise level was recorded in CD (97.80 ± 2.91 dBA), this finding is consistent with the finding of Kracht *et al.*<sup>(23)</sup> in 2007, where the peak noise level during surgery in operation rooms were well in excess of 100 dBA. In the present study, the emotional outburst of the relatives of the injured and deceased and vehicular movement in that area might have contributed to the observed noise level. The lowest level of noise was observed in CCU and RCU of Ibn-Sena General TH (85.46 ± 4.81 dBA), which may be due to restricted visits of relatives. It is surprising to note that even the lowest recorded noise level was 45 dBA higher than the recommended WHO level of 40 dBA for morning hours. The WHO guidelines for noise in hospitals state that Leq levels should not exceed 35 dBA in most rooms in which patients are being treated or observed. They also stated that, on wards, noise levels should not exceed 30 dBA Leq (day and night) and that peak noise levels at night should not exceed 40 dBA. Such high level could slow down the recovery of patients<sup>(24, 25)</sup>.

The findings of the present study in respect to  $L_{min}$  and  $L_{max}$  were higher than those recorded in the wards of two general TH in Ibadan (63 – 89 dBA) in an earlier study carried out by Omokhodion and Sridhar during 2002<sup>(26)</sup>.

In the present study the average indoor noise levels of the three teaching hospitals were found to exceed the permissible limits<sup>(27, 28)</sup>. Many places even in silence zones had noise levels above 75 dBA. It was alarming to note that all areas in the three teaching hospitals had levels exceeding 75 dBA during the morning hours. The heavy inflow of about 6000 patients every day during the morning hours could probably be one of the contributing factors for such high levels.

Noise level had certain time-pattern. Thus, in the present study, the morning (8:00, 9:00, 11:00 a.m.) noise level was significantly higher ( $p = 0.037$ ) than the afternoon level, (94.35 Vs 90.14 dBA).

Unfortunately, the evening noise level could not be recorded due to logistic issues, difficult transportation and security circumstances which prevent the data collector from evening recording. This finding is similar to what was reported by Bharathan T *et al.*<sup>(29)</sup> in New York Methodist Hospital during 2007, although the level was lower than the stated by the current work (68.0 Vs 58.9 dBA). In a study carried out by Vinodhkumaradithyaa *et al.*<sup>(12)</sup> at Madurai–India in 2008, the mean equivalent noise level were 70.38 dBA in the morning and 64.46 dBA in the evening in a tertiary care hospital.

In the present work, the level of noise was significantly higher on weekdays (94.05 dBA) than on weekends (88.57 dBA), ( $p = 0.002$ ). This day-by-day pattern of noise is consistent with staff activities and clinical teaching sessions during the weekdays. Quieter THs on a weekend is explained by lower number of doctors, medical staff and visitors with no teaching activities and fewer procedures performance.

## CONCLUSIONS

The present work concluded that the noise pollution in Mosul MCCTHs greatly exceeded the WHO guideline level for hospitals. Time-and place-patterns of noise in Mosul Medical City Institutions followed activities of medical and non-medical staff and suggest that the noise pollution is mostly "manmade". Therefore, these results will be of help to planners and policy makers in the Nineveh Directorate of Health to combat such big problem, and there is a need for regular noise monitoring so as to establish an optimal hospital environment.

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