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https://doi.org/10.15017/1906161

出版情報：Proceedings of International Exchange and Innovation Conference on Engineering & Sciences (IEICES). 3, pp.79-84, 2017-10-19. Interdisciplinary Graduate School of Engineering Sciences, Kyushu University
バージョン：
権利関係：

IEICES

3rd International Exchange and Innovation Conference on Engineering & Sciences
Kyushu University, Fukuoka, Japan
October 19-20, 2017

# Assessment of Noise Exposure Impacts on Blood Pressure and Pulse Rate at Intensive Care Units in Gaza Strip-Palestine

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**Abstract:** *Noise pollution poses health risks on human specially at sensitive indoor environments like health facilities. This research aimed to examine the relationship between occupational noise levels, arterial blood pressure and pulse rate for employees at general intensive care units in Gaza Strip. The arterial blood pressure and pulse rate were examined before and after 5hours exposure to noise for 80 employees (72 males and 8 females). In this study, two instruments were used; Sound Level Meter and Automatic Blood Pressure Monitor. Correlation analysis was performed to examine the relationship between the variables. The results show that the noise levels at the intensive care units were found to be between 52.52 and 65.74 Decibel (dB) with a mean of 60.33 dB which is far beyond the WHO standard of 35 dB. There was a significant positive correlation between noise level and average of pulse rate. The research findings show the urgency in acting to reduce the noise levels which may pose health risk on the intensive care units occupants.*

**Keywords:** Blood Pressure, ICU, Noise Pollution, Pulse Rate.

## 1. INTRODUCTION

Noise, defined as unwanted sounds, can affect people both psychologically and physiologically [1]. Noise causes various health effects on humans, plants and animals [2]. It has become a very important "stress factor" in the environment of people. Health effects differ from one person to another according to several determinants like sound level, frequency and exposure's duration to noise pollution.

It is well known that excessive noise in working places can affect communication and alter human attitude. Due to their vital services as they are considered places for healing people, hospitals probably represent one of the most important environments which need full attention when it comes to noise pollution. Therefore, developed countries have taken serious considerations of the noise pollution issue in an attempt to reduce its negative impact, not only in hospitals, but in all aspects of daily life [3].

The acceptable SPL value in hospitals should not exceed 45.0 dB(A) during daytime and should not exceed 35.0 dB(A) during night-time based on the international standard [4]. World Health Organization (WHO) also recommends that the average background noise in hospitals during daytime should not exceed 30 A-weighted decibels [dB(A)], and that peaks during the night time should be <40 dB(A) [5]

The health effects of noise pollution have been studied by many researchers in recent years. Vertigo, agitation, weariness, hypertension, gastrointestinal system problems (including gastric and duodenal ulcer), cardiac arrhythmia, nervous and psychic disorders have been studied by several researchers ([6]; [7]). An additional study has found that noise can stimulate the bodies' stress response [8] and loud noise causes stress, annoyance [9], and fluctuation of blood pressure [10]. Investigations throughout the world have shown that the level of noise in the intensive care units (ICU) exceeds the acceptable standards [11]. The noise level in intensive care units (ICUs) ranges from 50 to 75 dBA, with the highest night peak level even reaching 103 dBA [12].

[13] measured the mean equivalent sound pressure levels (Leq) at ICU in few Indian hospitals during morning and evening hours, the findings showed that the noise levels were 70.4 and 64.5 dB(A), respectively.

[14] found that patients at ICU were disturbed and distracted mainly due to noise from the nurses' station, visitors, and other non-clinically relevant events. A number of studies have found that the environment in the intensive care units (ICU) has negative effects on patients and staff including sleep disturbance and annoyance [15].

[16] reported that noise levels in a four-bed ICU were between 60 and 65 dB(A). In Taiwan, measurements of sound level in hospitals were carried out and results showed that the daily average sound levels measured inside those hospitals during daytime were between 52.6 dB(A) and 64.6 dB(A) [17].

Studies have shown significant correlation between noise and its impact on artery disease including systolic and diastolic blood pressure, cholesterol concentration and plasma viscosity [18]. The chance of stroke occurrence was higher in people who were exposed to noise pollution than those who were not exposed to it according to the findings of study that was performed in Denmark on 57000 men and women for ten years [19].

[20] conducted a study on workers of a metal manufacturing company in Busan, a significant relationship between chronic noise exposure and increase in systolic BP was seen. [21] carried out a study on workers of a car manufacturing factory indicated that occupational noise exposure can facilitate Hypertension progression.

Many relevant research scientists worldwide have observed a significant rise in blood pressure in response to noise ([22]; [23]). [24] in Austria performed a study on children and found that systolic blood pressure increased due to noise exposure.

Another study in New York, comparing children in high noise schools with children in quiet schools, showed that blood pressure of children in the first schools were increased about 4-8 mmHg [25]. In 2007, the World Health Organization (WHO) published quantifying burden of disease resulted from some noise sources such as road traffic, trains and aircraft and their health effects on Europeans.

[10] shows that the average noise levels in three ICUs rooms at night range from 43.2 ± 0.5 to 53.9 ± 2.5 dB, with maximum levels often reaching 49.1 ± 1.0 to 61.1 ± 2 dB. Whereas the mean value of noise levels in the same rooms at day range from 44.3 ± 0.7 to 56.2 ± 2.2dB, with maximum levels often reaching 55.4 ± 1.0 to 67.1 ± 1.6 dB. Other studies agree with and support the findings of this research such as [26].

In Palestine, several studies were conducted on noise pollution, for example, strong positive correlation was found between occupational noise pollution levels and heart pulse rate, systolic blood pressure, diastolic blood pressure and hearing threshold levels at several frequencies ([27]; [28]). In addition, [29] studied noise pollution in factories in Nablus city, the average value of (Leq) in 38 factories was 85.5 dB(A), and the Leq values for 40% of the selected factories were higher than the adopted international standards [30].

[3] investigated the noise effect on blood pressure and pulse rate of medical workers at Nablus hospitals, the findings showed strong positive correlation between noise and blood pressure from one side and between noise and heart pulse rate from the other side in all hospital departments in Nablus City-Palestine. In this study SBP, DBP and HPR are positively correlated (P-value < 0.050) with the occupational noise levels in all studied hospitals.

[31] conducted a study on the effect of noise on hearing threshold, blood pressure, oxygen concentration in blood and heart pulse rate of workers at Jenin hospitals. In this study HTL, SpO2%, SBP, DBP and HPR are positively correlated (p-value < 0.050) with the occupational noise levels in all studied hospitals.

[32] carried out a research at Children Schools in Jenin City on the impact of noise on arterial blood pressure and heart pulse rate, this study shows that the measured sound pressure levels (SPL) in all tested schools were found to be above the acceptable international levels. Strong positive correlation was found between sound pressure levels in the sample schools from one side and blood pressures (R=0.96 for systolic and R= 0.98 dyastolic) and heart pulse rate (R=0.991) from the other side.

Noise pollution is a serious hazard which influences human health, and it's getting more serious in health facilities due to the sensitivity of the occupants. There are several sources of noise at ICU both from the device installed and the personnel who are utilizing the facility. There are few studies conducted to tackle this risk, hence the objectives of this research paper were to examine the noise trends at ICU's in Gaza local hospitals, investigate the physiological impacts of noise (systolic and diastolic blood pressure and pulse rate) on the ICU's staff, and to provide decision makers with helpful suggestions and recommendations.

## 2. MATERIAL AND METHODS

### 2.1. Study Design

Cross sectional analytical design was conducted, where noise, blood pressure and pulse rate were measured at one point in time**.**

### 2.2 Study Population

A census population was selected for this research, where all employees (doctors and nurses) who work at ICU's in the target governmental and non-governmental hospitals in Gaza Strip-Palestine. Noise levels were measured at six hospitals' ICU's. The hospitals of the study are five from the governmental sector (AL-Shifa, Nasser Hospital, The European Hospital, Al-Aqsa Martyrs Hospital, Kamal Udwan Hospital) and one non-governmental Hospital (AL- Quads Hospital).

The inclusion criteria involved male-and-female staff who are 22- 65 years of age and with a minimum of one year in the service. While employees who have history of heart problems or diseases were excluded.

### 2.3 Noise Monitoring

The noise level measurements were carried out weekly on Sunday, Tuesday, and Thursday in each ICU in both morning and evening shifts starting at 7:30 a.m. to 18:30 p.m. over a period of two months. Sound pressure level (SPL) was taken every 5 minute in morning shift at time intervals of 7:30 -8:30 am, 9:30 -10:30 am and 11:30 am-12:30 pm.

While in the evening shift, the monitoring was done on the following times; 13:30 - 14:30 pm, 15:30 -16:30 pm and 17:30 -18:30 pm, then average was calculated, the min and max of each hour measurments were figured out. Average of (SPL) at the beginning of morning and evening shift (before work) was taken to compare it with the morning and evening shift' average of (SPL) after working. The readings of SPL in all ICUs were taken by using sound level meter with A-weighting.

These measurements were performed inside ICUs (indoors) for the aforementioned period. Several locations in each ICU were selected for sound level measurements, including nursing stations, center of the unit and beside the beds. Sound levels were measured using sound level meter, and measurements were done at the hearing level of about 1.5 m above ground surface. Data was analysed statistically using the SPSS and Microsoft Excel.

The systolic and diastolic blood pressure and pulse rate of the employees were measured by using Automatic Blood Pressure Monitor. Each of the selected employees in the ICUs; works at least 6 hours. The systolic and diastolic blood pressures and heart pulse rate were measured for each selected doctor and nurse twice a day for three fixed days a week (Sunday, Tuesday, Thursday) in each ICU in both morning and evening shifts over a period of two months, the readings were recorded before and after 5 hours work shift. The measurement was performed while each employee sitting on a chair after at least five minutes of rest in order to ensure they are in resting condition.

### 2.4 Devices and Tools

#### 2.4.1 Sound Pressure Level Meter:

Sound Level Meter, is the instrument used to measure the noise level in dB. It is designed to simulate the loudness level sensitivity of the human ear. It gives objective, reproducible measurements for the sound pressure level. The microphone converts the sound to an equivalent electrical signal, which varies in with the acoustical signal. The noise levels were measured using the Auto range digital multimeter (MASTECH), China, model MS8209 5 in 1, integrating and logging sound level meter, in (dB) units with an accuracy of ± 3.5% dB at 94dB and its resolution is 0.1 dB(A), measuring range is 35 – 100dB [33].

**2.4.2 Blood Pressure Monitor :**

Arterial blood pressure (systolic and diastolic) and pulse rate were measured using Automatic Blood Pressure Monitor (Riester ri-champion N, Type of model: digital, Germany, model No:RST -1725- 145, size (98X 163 X 106mm), Measuring range: SYS / DIA : 30 to 280 mmHg, pulse : 40 to 200 per minute with accuracy : pressure within ± 3 mmHg and pulse ± 5% of the reading with operating temperature range of +10 to +40 Co [34].

**2.4.3 Questionnaire:**

About 80 copies of the structured questionnaires were prepared to obtain Socio-demographic data from the participants. The data in the questionnaire included: (name, mobile number, age, gender, marital status, job, qualification, hospital, years of work, employees history of hypertension, employees history of other diseases and living place).

Further, the questionnaire contains a table to record systolic, diastolic blood pressure and heart pulse rate of the employees twice a day for three fixed days a week (Sunday, Tuesday and Thursday) in both morning and evening shifts, the readings were recorded before and after work, at least five hours from the beginning of work.

To ensure the validity of the questionnaire, it was submitted to a panel of experts to evaluate the content and validity. Crombach Alpha and correlation coefficient were done to ensure reliability of the questionnaire. Small scale reliability test (pilot study) was conducted to have an idea about length and ambiguity of the questionnaire.

**3.4.4 Statistical Analysis:**

The obtained measurements and readings were tabulated and statistically analyzed. The statistical package of social science (SPSS) was used for statistical analysis. The minimum, the maximum and the mean of each studied variable were listed. Consequently, Independent Samples T-test and Paired Samples t- test are used to determine significant differences between variables. Pearson correlation factor (R) and the P-value were used as an indicator of the correlation's strength between variables.

## 3. RESULTS AND DISCUSSION

The survey results show that the employees ages were between 24 to 57 years of age and the work experience varied from 1 to 30 year. In terms of gender, the study population included 90% males and about 10% females. Moreover, the study sample consisted of 36% physicians and 64% nurses. 8.8% of the sample participants were hypertensive and 91.2% were non-hypertensive. The results also reveal that 67.5% of the study population participants were morning shift workers while 32.5% were working in the evening shift. The average, maximum and minimum values of SPL in all studied ICUs are shown in (Fig. 1).

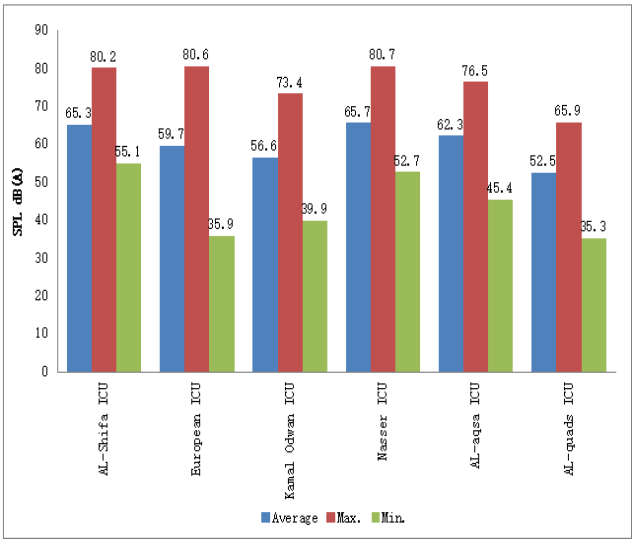


Fig. 1. The average, maximum and minimum values of SPL in all ICUs

As shown in (Fig. 1) the highest noise levels were recorded at Nasser ICU and Al-Shifa ICU; 65.74 dB(A)-65.4 dB(A) respectively, which is considered to be very noisy. While the intermediate noise levels were registered at Al-Aqsa ICU and European ICU with levels of 62.21 dB(A) and 59.38 dB(A) respectively, which is still considered to be noisy. Whereas both Kamal Odwan ICU and AL-quads ICU had the lowest values of noise levels; 56.74 dB (A) 52.52 dB(A) respectively and they considered to be the least noisy environments.

AL-Shifa ICU has the highest levels of noise due to the largest number of staff and patients; adding to that the incoming alarms from devices, while Nasser ICU is very small size and includes large number of patients and staff. These factors might have an influence on increasing the SPL in the ICUs. These values (65.74-65.4 dB) are much higher than the international standard of 45.0dB during daytime and 35.0 dB during night-time [4]. Also the mean SPL values in all studied ICUs ranged from 52.52 to 65.74 dB with a mean of 60.33 dB. The results of this research are in line with the findings of [31] who reported similar values for noise at hospitals ICU's in Jenin-Palestine which were between 55.0 and 65.0 dB(A), and another study by [3] who reported noise levels between 59.7 and 76.0 dB(A) at ICUs in the Hospitals of Nablus-Palestine, respectively.

A similar early study on the assessment of noise conducted by [35] Saudi Arabia, in the ICU of King Fahad University Hospital supports the findings of this study. This study shows the average 59.3±6.376 in over measured 3 days and 57.9±4.743 in weekend day's. Other studies support our finding in SPL measurement such as [15] which reported values between 60 and 65 dB(A) in a four-bed ICU with noise levels above 65 dB(A) during teaching and [36] measured the average

daytime sound level in a pediatric intensive care unit was 61 dB (A), nighttime 59 dB (A).

The research outcomes showed that there was an increase in the SPL, which coincided with the rise of average SBP, DBP and PR for all employees in all studied ICUs. For example, the results of Nasser ICU showed that the mean SPL during work was 65.74dB which is higher than the mean SPL at the beginning of work which was 59.71dB, this was accompanied by an increase in average value of SBP mmHg, DBP mmHg and PR(beats/minute) after work (121.27 mmHg, 75.80 mmHg and 83.29(beats/minute)) respectively.

When compared with the readings before starting the work shift, values were as follow 117.28 mmHg, 72.35 mmHg and 79.40 (beats/minute) respectively. The results also showed that there was an increase in average, maximum and minimum values for SBP, DBP and PR after work for all studied employees in ICUs when compared to values before starting the work shift.

The findings of this research conformed with the results of other studies of noise-induced blood pressure elevation and higher incidence of hypertension which were detected in field studies on employees who were exposed to high levels of noise ( [18]; [40] )

Moreover, this research findings are consistent with the studies of ([39] ; [3]; [31]; [32] ) which show that SBP, DBP and HPR are correlated positively (P- value < 0.050) with the occupational noise levels in all studied locations.

The actual mechanism for increase in blood pressure is not completely understood yet, but it may be due to the following mechanisms: The catecholamine released from adrenal medulla as a result of activation of adrenergic system, the effect of suprarenal glands steroids, angiotensin and also the direct effect of noise on arterial wall tension that influences the blood pressure and heart rate [40].

Table (1) shows that the correlation coefficient between noise level and the three indicators SBP, DBP, and PR. The correlation coefficient between noise level and average of (SBP and DBP) equals 0.158 and 0.091 respectively. It was concluded that there is insignificant positive relationship (p-value > 0.05) between noise level and average of (SBP and DBP). Whereas the correlation coefficient between noise level and average of PR equals 0.274, moreover there was a significant positive relationship (p-value < 0.05) between noise level and average of PR. These results were consistent with study of [41] which stated that there was no significant relationship between BP and noise exposure.

Table (1): Pearson Correlation Coefficients between noise and the three indicators

| | Exposure | | |
|---|---|---|---|
| **Variables** | **Pearson Correlation** | **P-value** | **N** |
| Average of SBP(mmHg) | 0.158 | 0.161 | 80 |
| Average of DBP(mmHg) | 0.091 | 0.423 | 80 |

*Correlation is significant at the 0.05 level.

Table (2) shows that the Pearson correlation coefficient between age and each of SBP, DBP, and PR. The correlation coefficient between average of "SBP, DBP and PR" with "age" equals 0.339, 0.361 and 0.186, respectively. Since the sign of the correlation coefficient is positive and the p values < 0.05, it can be concluded that there is a positive significant relationship between average of "SBP, DBP and PR" and the employees' age categories.

Table (2) Correlation coefficient between "SBP, DBP and PR " and "Age"

| **Variable** | **Pearson Correlation Coefficient** | **P-Value** |
|---|---|---|
| Average of SBP(mmHg) | 0.339 | 0.001* |
| Average of DBP(mmHg) | 0.361 | 0.000* |
| Average of HPR(beat\min) | 0.186 | 0.049* |

* Correlation is statistically significant at 0.05 levels

As shown in Table (3); Pearson correlation coefficient between number of service years and each of SBP and DBP. The correlation coefficients were 0.352 and 0.403 respectively, since the sign of the correlation coefficient is positive and p value <0.05, it means that there is a positive significant relationship between average of "SBP and DBP" with "number of service years". Whereas the correlation coefficient with the average of PR was 0.146. It is concluded that there is an insignificant positive relationship (p-value > 0.05) between average of PR and duration of service.

Table (3) Correlation coefficient between " SBP, DBP and PR " and "years of work"

| **Variable** | **Pearson Correlation Coefficient** | **P-Value** |
|---|---|---|
| Average of SBP(mmHg) | 0.352 | 0.001* |
| Average of DBP(mmHg) | 0.403 | 0.000* |
| Average of PR(beat\min) | 0.146 | 0.098 |

* Correlation is statistically significant at 0.05 levels

## 4. CONCLUSION

The average noise levels at the monitored ICUs were as follows; 65.74 dB in Nasser ICU, 65.4 dB in AL-Shifa ICU, 62.21 dB in Al-Aqsa ICU, 59.38 dB in European ICU, 56.74 dB in Kamal Odwan ICU and 52.52 dB in AL-quads ICU. These levels are exceeding the international standard 0f 45.0 dB at daytime and 35.0 dB at night-time Also the mean SPL values in all studied ICUs ranged from 52,52 to 65.74 dB(A) with mean of 60.33 dB(A). Therefore, all the sample workers are exposed to high continuous noise in all ICUs.

There was an increase in the SPL coincide with the rise of average SBP, DBP and PR for all employees in all studied ICUs. Where SBP and DBP might be affected by the person's physical, mental and health conditions (Iyawe, 2000). Furthermore, SBP mean increased by 3.74 mm-Hg, while DBP mean increased by 2.79 mm-

Hg, and finally, the pulse rate mean is increased by 2.69 beats/minute for all employees in the studied ICUs.

This study revealed that there was a significant positive relationship (p-value < 0.05) between noise level and average of PR, and it was found that the SBP, DBP and PR in males are influenced more by noise compared to females where there was a significant difference (P-value < 0.050) in the mean of SBP and DBP (before and after work shift). Positive significant correlation (P-value < 0.050) was found between mean values of "SBP, DBP and PR" with" age of employees", also there was a positive significant correlation (P- value < 0.050) between mean values of "SBP and DBP" with "number of service years".

To tackle this serious challenge at ICU's which puts the occupants at risk, its suggested that hospitals design should take into consideration widening the spaces between patients beds, also between patients beds and medical staff equipment. Noise caused by machines can be reduced through applying several mechanical adjustments, conducting maintenance, or buying new less noisy equipment. Noise from reflecting surfaces can be reduced by covering all surfaces with anti-reflection materials of high noise absorbents and noise from the doors can decreased by using rubber. Isolating walls and double glass can be used for windows and doors to reduce the external noise and avoidance of unnecessary conversation among staff.

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