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Health effects of occupational noise exposure in the range (90 - 110) dB(A) especially on blood oxygen saturation of workers in selected industrial plants

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ABSTRACT

This study shed the light on the effects of occupational noise level on some of the dependent variables, such as: blood oxygen saturation (SPO_2%), pulse rate (P.R), arterial blood pressure (systolic (SBP) and diastolic (DBP)), and hearing threshold levels (HTL). 115 workers of both genders (96 male, 19 female), with mean age 35.22 yr, and the mean duration of employment 6.99 yr, were randomly chosen as a sample to fulfill the aim meant.

This sample was taken from seven industrial plants of various types in Jenin city. The values of sound pressure levels (SPL) in all studied plants ranged from 82.5 dB(A) to 110.5 dB(A), with mean of (94.34 dB(A)). A number of measurements concerning with blood oxygen saturation, pulse rate, arterial blood pressure (systolic and diastolic), and hearing threshold levels at different frequencies were taken for the selected sample before and after 6 hours exposure to noise. Strong positive correlation (Pearson Correlation Coefficient) with SPL was found for all measured variables. The statistical results for the dependent variables (SPO_2%, P.R, SBP, DBP, HTL) showed that Pearson correlation coefficient (R) between sound pressure level and the dependent variables are approximately equal to one, and the Probabilities (P) are < 0.05.

This study showed that the health effects of noise depend on the noise level itself, more specifically, workers exposed to noise more than 90 dB(A) have a significant shift of the mean measured values (blood oxygen saturation, pulse rate, arterial blood pressure (systolic and diastolic), and hearing threshold levels), more than workers exposed to noise less than 90 dB(A).

INTRODUCTION

People throughout the world are facing many unpleasant pollution effects such as air pollution, water pollution and noise pollution which are seriously influencing human's life.

The term noise is commonly used to describe sounds that are disagreeable or unpleasant produced by acoustic waves of random intensities and frequencies[3]. Some authors define noise as any audible acoustic energy that adversely affects the physiological or psychological well being of the people[5]. However, noise is measured using a logarithmic decibel (dB) and can be described by the help of loudness (intensity) and pitch (frequency).

Because of the rapid growth in technology that has mainly occurred in urban countries not only in the developed one, but also in the developing countries as well, noise pollution has become one of the major threats that face the environment and the cost of reducing it in future years is expected to be insurmountable[10].

Noise pollution is not only an environmental problem, but also a serious health risk. The World Health

Organization (WHO) has established maximum allowable levels of noise, above which people are harmed. Proportion of people exposed to noise is greatly increasing; this has direct and indirect effects on people and can lead to the health hazards. Some of the major health hazards caused by noise are: decrease in blood oxygen saturation, permanent hearing loss, high blood pressure, muscle tension, headaches, higher cholesterol levels, irritability insomnia, and psychological disorder[13].

Literature review

A study carried out by Zahr and Balian on 55 preterm infants between 23 and 37 weeks, exposing them to common ICU environmental noises such as alarms, phones and loud conversations, it was found that the average blood oxygen saturations were significantly lower during noisy periods[18].

In a study conducted at Peshawar and Palestine[1,2,11,15,17], it was noted that there was a significant rise in blood pressure and heart pulse rate in response to noise.

In Germany and other developed countries as many as 4 to 5 million that is 12-15% of all employed people, are exposed to noise levels of 85 dB(A) or more. That results in 20% or more of employers suffer from hearing impairment (WHO, 2001). In 1998 to 2000, it was estimated that approximately 28 million Americans suffer from hearing loss and almost 10 million Americans suffer from noise induced hearing loss (NIHL)[16].

OBJECTIVES OF THE STUDY

The aims of this study are

(1) Measuring noise levels generated by different machines sources in factories.

(2) Determining the effect of occupational noise on blood oxygen saturation, hearing threshold levels, systolic and diastolic blood pressure and pulse rate in the range (90-110) dB(A) level.

(3) Comparing the effects of noise pollution on blood oxygen saturation in the range (80-90) dB(A) and (90-110) dB(A) levels.

Theoretical background of blood oxygen saturation

One hemoglobin molecule can carry a maximum of four molecules of oxygen. If a hemoglobin molecule carries three molecules of oxygen, then it carries 3/4 or 75% of the maximum amount of oxygen it could carry.

Healthy blood oxygen saturation is between 95 and 100 percent. Patients with blood oxygen levels below 90 percent are considered to have hypoxemia, and a blood oxygen level below 80 percent is known as severe hypoxemia. Shortness of breath is the primary symptom of hypoxemia[12].

Blood oxygen saturation level can be determined using a pulse oximeter. A pulse oximeter is a particularly convenient measurement instrument. Typically it has a pair of small light-emitting diodes (LEDs) facing a photodiode through a transparent part of the patient's body, usually a fingertip. One LED is red, with wavelength of 660 nm, and the other is infrared with wavelengths 905nm or 940 nm. Absorption at these wavelengths differs significantly between oxyhemoglobin and its deoxygenated form. Therefore, the oxyhemoglobin / deoxyhemoglobin ratio can be calculated from the ratio of the absorption of the red and infrared light[14].

METHODOLOGY

Study sample

The sample of this study was 115-worker, including 96 male and 19 female, distributed in these different factories. The sample's ages were between 18-60 years. The subjects chosen had no history of heart, cardiovascular disease, and hearing impairment. In addition the selected workers had at least a one year work, with average working hours (8-12 hours) per day. In order to select study sample from a random one the following formula was used:[4].

$M = n / \{1 + [n/N]\}$

Where: M: correlation sample size that should be used. n: best value to select a random sample of workers in each factory = $Z^2 P q / \delta^2$.; N: the actual sample number of workers that found in each factory.; $\delta = 0.055$, $Z = 1.96$ (constant), $P = 0.9$, $q = 1 - P = 0.1$.

Stages of study

Several stages were performed

(1) Choosing the industrial plants and measuring the sound pressure levels of these plants.

(2) Classifying the factories into different categories according to sound pressure levels in the range (80-90 dB(A)) and (90-110 dB(A)).

(3) Regular visits to these factories were done in order to measure several health parameters during the morning shift and after 6 hours working (between 7.00am and 13.00 pm). However the tested parameters are summarized as:

(4) Blood oxygen saturation. b. Hearing threshold. c. Arterial blood pressure (systolic and diastolic). d. Pulse rate.

Measurements and instrumentations

Sound pressure level measurement

The Sound Pressure Level Meter (Instructions manual 1998 b) was used in this study to measure the occupational noise in each factory, has an accuracy of ± 0.5 dB(A) at 25ºC, with precision of 0.1 dB(A)

Blood oxygen saturation

Blood oxygen saturation was taken for every worker twice a day, before starting the work and after 6 hours of beginning working. The instrument used for this purpose was Pulse -Oximeter LM-800 (Finger - Oximeter) with accuracy ± 1%(Instructions Manual, 2012).

Hearing threshold

To evaluate the subject's hearing ability an Audiometer (Instruction Manual, 2010) with accuracy ±2%, at operating temperatures 15 ºC to 40 ºC was used for different workers at different frequencies; 250, 500, 1000, 2000, 4000.6000. 8000 HZ.

Blood pressure and pulse rate

Automatic Digital Electronic Wrist Blood Pressure Monitor (model WS-300) with accuracy ± 2 mm-Hg, and ± 1% for reading heart pulse rate with operating temperature range of +10 ºC to +40 ºC (Instruction Manual, 1998a) was used to measure The blood pressure (systolic and diastolic) and pulse rate.

RESULTS

The measured equivalent sound levels (L_{eq}) in all selected industrial plants are presented in TABLE 1. Number of selected workers and working hours per day in each selected plant are also shown in this TABLE.

TABLE 1 : Noise pollution levels (NPL) in dB(A) at the studied plants

Plant type/Name	L_{eq} in dB(A) Mean value	Number of selected workers	Working hours per day
Metal (Hadad factory)	95.6	20 male	12
Chemical (Albareeq factory)	93.7	15 male	9
Concrete	102.4	21 male	8
Food	82.5	10 male	8
Sewing(Clothes)	90.2	19 female, 10 male	10
Stonecutter	110.5	15 male	8
Carpentry	85.5	5 male	8

This study showed that the health effects of noise on human depend on the noise level itself. More specifically, the workers exposed to noise more than 90 dB(A) have stronger health effects compared to those exposed to occupational noise less than 90 dB(A) as can be shown in TABLE 2.

TABLE 2 : Net change of blood oxygen saturation, pulse rate, and blood pressure (systolic and diastolic) before and after exposure in two groups of factories

Difference between means	Factories for SPL more than 90 dB(A)	Factories for SPL less than 90 dB(A)
SPO_2%	1.64	1.33
P.R beats/min	3.68	2.8
S.B.P mmHg	5.05	3.73
D.B.P mmHg	4.21	3

There are significant hearing threshold shifts in right and left ears of subjects before exposure to occupational noise and after 6 hours from the beginning of morning shift TABLE 3.

This study showed that the blood oxygen saturation values before exposure to noise is close for the various groups of workers, and these values are decreased after exposure to occupational noise. The behaviors of blood oxygen saturation as dependent variable showed continuous decrease with occupational noise levels (Figure 1), age (Figure 2), and the duration of employment (Figure 3) as independent variables. The strength of the results is good as can be understood from the Pearson correlation coefficient (0.779) and the Probability (0.039) between sound pressure level (SPL) and blood oxygen saturation (TABLE 4). In ad-

TABLE 3 : Percentage of degrees of hearing impairment in each studied industrial plant [according to OSHA's definition of hearing impairment]

Industrial Plants	SPL (dB(A)	Right ear (b) %	Right ear (a) %	Left ear (b) %	Left ear (a) %
F_1	95.6	8/ 20 (40%)	11/ 20 (55%)	9/ 20 (45%)	14/ 20 (70%)
F_2	93.7	2/15(13%)	4/15 (26%)	2/15 (13%)	5/15 (33%)
F_3	102.4	9/21(42%)	14/21 (66%)	8/21 (38%)	11/21 (52%)
F_4	82.5	2/10 (20%)	3/10 (30%)	1/10 (10%	2/10 (20%)
F_5	90.2	Male: 2/10 (20%) Female: 5/19 (26%) Total: 7/29 (24%)	Male: 4/10 (40%) Female: 10/19 (52%) Total: 14/29 (48%)	Male: 3/10 (30%) Female: 6/19 (31%) Total: 9/29 (31%)	Male: 5/10 (50%) Female: 11/19(57%) Total: 16/29 (55%)
F_6	110.5	7/15 (46%)	10/15 (66%)	6/15 (40%)	10/15(66%)
F_7	85.5	1/5 (20%)	1/5(20%)	2/5(40%)	2/5 (40%)
Total	_____	36/115 (31%)	57/115 (49%)	37/115 (32%)	60/115 (52%)

Average of hearing threshold levels in either one or both ears exceed 25 dB(A) at 1000, 2000, and 3000 Hz.; ** F_1: Metal (Haddad), F_2: Chemical (ALbareeq), F_3: Concrete, F_4: Food, F_5: Sewing (Clothes), F_6: Stonecutter, F_7: Carpentry

TABLE 4 : Pearson correlation coefficient between sound pressure levels (SPL) in dB(A) and blood oxygen saturation (SPO_2%), pulse rate (P.R), arterial blood pressure (SBP & DBP), and hearing threshold levels (HTL) at different frequencies

Independent variable, dB(A)	Dependent variables	Pearson Correlation coefficient (R)	Probability (P)
SPL	SPO2%	0.779	0.039
SPL	P.R	0.790	0.035
SPL	SBP	0.734	0.030
SPL	DBP	0.795	0.033
SPL	R 250 Hz	0.877	0.009
SPL	L 250 Hz	0.935	0.002
SPL	R 500 Hz	0.891	0.007
SPL	L 500 Hz	0.945	0.001
SPL	R 1000 Hz	0.914	0.004
SPL	L 1000 Hz	0.954	0.001
SPL	R 2000 Hz	0.715	0.071
SPL	L 2000 Hz	0.738	0.058
SPL	R 3000 Hz	0.747	0.054
SPL	L 3000 Hz	0.790	0.035
SPL	R 4000 Hz	0.826	0.022
SPL	L 4000 Hz	0.874	0.010
SPL	R 6000 Hz	0.626	0.133
SPL	L 6000 Hz	0.720	0.068
SPL	R 8000 Hz	0.645	0.118
SPL	L 8000 Hz	0.663	0.104

SPL: Sound pressure level in dB(A), SPO_2%: Blood oxygen saturation, P.R: Pulse rate (beats/ min), SBP: Systolic blood pressure (mmHg), DBP: Diastolic blood pressure (mmHg), R: Right ear, L: Left ear, 250-8000 Hz: Frequencies which were used to detect the hearing levels of workers

TABLE 5 : Paired samples correlation of all studied variables before (b) and after (a) exposure to occupational noise in all studied industrial plants

Paired variables	Pearson Correlation coefficient (R)	Probability (P)
$SPO_{2\%}$ (b) & $SPO_{2\%}$(a)	0.714	0.042
P.R (b) & P.R (a)	0.990	0.000
S.B.P (b) & S.B.P (a)	0.891	0.003
D.B.P (b) & D.B.P (a)	0.906	0.002
R 250 Hz (b) & R 250 Hz (a)	0.994	0.000
L 250 Hz (b) & L 250 Hz (a)	0.992	0.000
R 500 Hz (b) & R 500 Hz (a)	0.964	0.000
L500 Hz (b) & L 500 Hz (a)	0.933	0.000
R 1000 Hz (b) & R 1000 Hz (a)	0.990	0.000
L 1000 Hz (b) & L 1000 Hz (a)	0.991	0.000
R 2000 Hz (b) & R 2000 Hz (a)	0.981	0.000
L 2000 Hz (b) & L 2000 Hz (a)	0.987	0.000
R 3000 Hz (b) & R 3000 Hz (a)	0.927	0.003
L 3000 Hz (b) & L 3000 Hz (a)	0.913	0.002
R 4000 Hz (b) & R 4000 Hz (a)	0.938	0.002
L 4000 Hz (b) & L4000 Hz (a)	0.911	0.001
R 6000 Hz (b) & R 6000 Hz (a)	0.951	0.001
L 6000 Hz (b) & L 6000 Hz (a)	0.905	0.001
R 8000 Hz (b) & R 8000 Hz (a)	0.923	0.001
L 8000 Hz (b) & L 8000 Hz (a)	0.947	0.001

dition the Pearson correlation coefficient and the Probability between blood oxygen saturation before and after exposure to noise are 0.714, 0.042, respectively (TABLE 5), but the values of pulse rate (P.R) and arterial blood pressure (systolic (SBP) and diastolic (DBP)) are increased after exposure to occupational noise during work. The behaviors of the pulse rate and arterial blood pressure (systolic and diastolic) as dependent variables showed a continuous increase with occupational noise levels (Figure 4), age (Figure 5), and duration of employment (Figure 6) as independent variables. The sta-

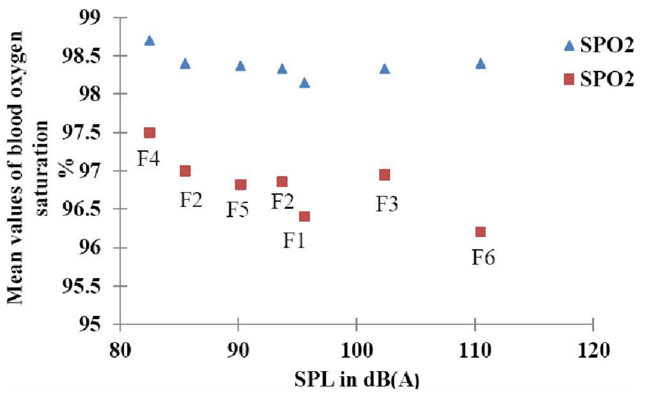
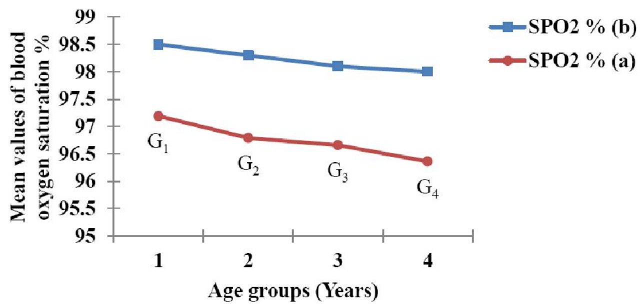
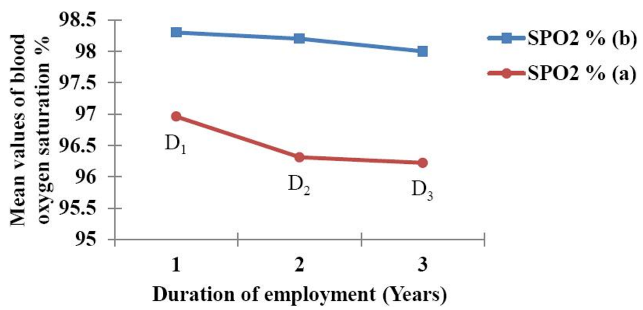


Figure 1 : Mean values of blood oxygen saturation (SPO_2%) of workers according to sound pressure levels (SPL) in each industrial plant



Age groups: G_1: 16-25 yr, G_2: 26-35 yr, G_3: 36-45 yr, G_4: more than 45 yr

Figure 2: Means values of blood oxygen saturation (SPO_2%) of all selected workers before and after exposure to noise according to different age groups



Duration of employment groups: D_1: 1-9 yr, D_2: 10-18 yr, D_3: 19-27 yr

Figure 3: Means values of blood oxygen saturation (SPO_2%) of all selected workers before and after exposure to noise according to different duration of employment groups

tistical results for the dependent variables (P.R, SBP, and DBP) showed that Pearson correlation coefficients between sound pressure level and the dependent variables are approximately equal to one, and the Probabilities are < 0.05. This indicates that there is strong correlation between SPL and the dependent variables TABLE 4. In addition the Pearson correlation coefficient and the probabilities TABLE 5 showed that there is significant correlation between the dependent variables before and after exposure to noise.

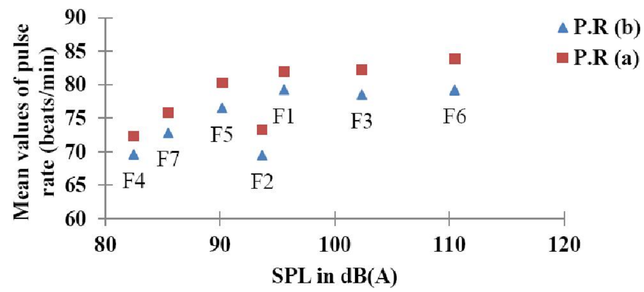


Figure 4 : Mean values of pulse rate (P.R) of workers according to sound pressure levels (SPL) in each industrial plant

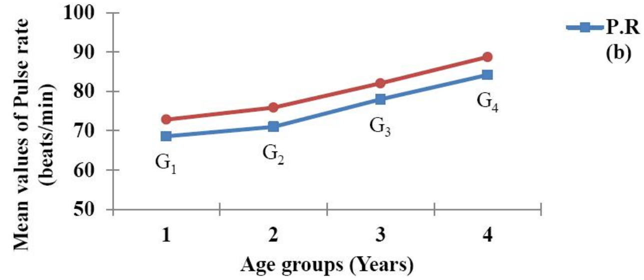


Figure 5 : Means values of Pulse rate (P.R) of all selected workers before and after exposure to noise according to different age groups

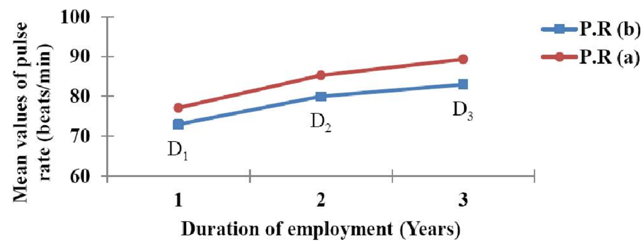


Figure 6 : Means values of pulse rate (P.R) of all selected workers before and after exposure to noise according to different duration of employment groups

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