An-Najah National University
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Effects of Noise Pollution on Arterial Blood Pressure, Pulse Rate and Hearing Threshold in School Children

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DEDICATION

THIS THESIS IS DEDICATED TO MY MOTHER, THE MEMORY OF MY FATHER, AND TO MY BROTHER AND SISTERS, WITH LOVE AND RESPECT

Acknowledgement

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List of abbreviations

Ali Primary School for Girls	S4
American National Standard Institute	ANSI
Decibel	dB
Decibel, by the A-weighted	dB(A)
Diastolic blood pressure	DBP
Equivalent noise level	L_{eq}
Hertz (cycles per second)	H_Z
Housing and Urban Development	HUD
International Standard Organization	ISO
Ischemic heart disease	IHD
Noise level in dB(A) exceeding N% of the measured time where N is from 1 to 99	L_N
Noise pollution level	L_{NP}
Pearson Correlation Factor	R
Permissible exposure limit	PEL
Pulse rate	P.R
The Occupational Safety and Health Act	OSHA
Root Mean Square	RMS
Seida Primary School for Boys	S1
Seida Primary School for Girls	S2
Sound pressure level	SPL
Standard error	SE
Systolic blood pressure	SBP
Tariq Primary School for Boys	S3
Tulkarem Camp Primary School for Boys	S5
Tulkarem Camp Primary School for Girls	S6

Abstract

This study reports the association of noise pollution level with blood pressure (systolic and diastolic), pulse rate and hearing threshold in school children. The schools were selected randomly as to represent quiet (Seida village, 77.8 - 85.2 dB(A)), noisy (Nablus city, 92.2 – 96.1 dB(A)), and very noisy, (Tulkarm refugees camp,100.4 – 108 dB(A)) localities. Strong positive correlation (Pearson correlation coefficient) was found between noise pollution level and systolic and diastolic blood pressure, pulse rate, and hearing threshold at different frequencies. The mean systolic and diastolic l blood pressure for the two sexes are correlated positively with the noise pollution level (R=0.521 and 0.440, respectively). The hearing threshold levels of different frequencies correlated positively with the noise pollution level (R= 0.114 to 0.267; where $p<0.05$).

Chapter 1

General Introduction

1.1 Definitions

Noise pollution may be defined as an unwanted sound. Sound is a physical disturbance in a medium that is capable of being detected by the human ear. Sound waves in air are caused by variations in pressure above and below the static value of atmospheric pressure (approximately 105 dyne/cm^2 at sea level at 0 ^{0}C) (Harris, 1979).

1.2Noise pollution

Noise pollution in West Bank towns and cities is increasingly becoming more evident because of the increasing number of noise sources such as markets, factories, vehicles and aircrafts (Abdel-Raziq *et al.*, 2000). Noise measurements permit precise and scientific analysis of annoying noise and give clear indications when sound may cause hearing damages and other effects. Moreover, measurement and analysis of noise levels are powerful diagnostic tools in noise reduction programs from airport, factories, highways, homes and recording studios. Therefore, they can be considered as tools that permit the improvement of quality of human life.

Noise is now considered as one of major environmental pollutants. Much is known about the noise with which we are forced to be acquainted day to day. However, little is known about the psychological and physiological aspects of exposure to noise. In addition, even in industry where noise is defined as a problem and treated as such little understanding has been achieved (Barrekette, 1974). Noise pollution is becoming increasingly more severe in industrial countries such as USA, and the cost of alleviating it in future years is expected to be insurmountable. Immediate and serious attention must be given to control this mushrooming problem, since the overall loudness of environmental noise is doubling every ten years (Cheed, 1970). This has inhanced scientists to discuss and study the effects of noise pollution on human's health and their capability intake of high or low doses of sound pressure levels as measured in decibel. The Federal Occupational Safety and Health Act (OSHA), administrated by the U.S Department of Labor, requires that specified noise exposures not be exceeded. These are guidelines for safe exposure. OSHA permissible noise exposures are given in Table 1.1 (see detailed guidelines in Table A.1) (Stumpf, 1980).

Table 1.1 OSHA permissible noise exposures

Time permitted per day (hr)	Sound level dB(A)
16	85
12	87
8	90
6	92
4	95
3	97
2	100
1 ½	102
1	105
½	110
¼ or less	115

1.3 Effect of noise pollution on human health

Excessive noise pollution has been blamed not only for hearing damage and community annoyance but also for hypertension, fatigue, heart trouble, serum lipid, triglycerides, platelet count, plasma viscosity, glucose, and reduced motor efficiency (Lord *et al.*, 1980; Babisch *et al.,1993;* Melamed *et al.,*1997; and Recova *et al.*, 1995).

1.3.1 Physiological effects

The physiological effects of noise may be classified into short-term and long-term effects (Webb, 1978). Short-term effects are those which persist for minutes, e.g., an eyeblink resulting from a short explosive sound, reflexes involving voluntary muscles, and others (Webb, 1978). Long-term effects are measured in hours, days, or longer. Long-term effects include responses such as alteration in rate of secretion of hormones into the blood concentration for hours, days, or longer with various real or postulated functional consequences (Cyril, 1979).

1.3.2 Effects on hearing

The main physiological effect of noise is that the inner ear may become damaged, either acutely, due to sounds of very high intensity range, such as explosions, or gradually as a result of long exposure to high industrial noise level range (Webb, 1978). Hearing damage, speech masking, and annoyance are the best-documented effects of noise on human beings (Lord *et al.*, 1986). Since ear's sole function is to "hear", i.e., to receive acoustical waves and convert them for interpretation by the brain, any action, which interferes with this function, is undesirable. Therefore, noise affects the hearing function of the ear in two ways: (1) it may cause permanent physical damage to the hearing mechanism, rendering it insensitive to important components of sound, and (2) it may mask or drown out desirable sounds (Lord *et al.*, 1986).

1.3.3 Other effects

Other noise pollution effects observed in humans include changes in the electrical activity of the brain, in heart and respiration rate, and in gross motor activity. Other effects have been noted including changes in the size of several glands of endocrine system, blood pressure changes, constriction of the blood vessels, dilation of the pupil of the eye, and observations of irritability, nausea, fatigue, anxiety, and insomnia (Webb, 1978). Apart from these physical changes, noise can cause psychological disturbances. Interruption of sleep by noise can cause people to become irritable and resentful against the cause of noise. Speech communication can be impaired by noise masking resulting in inefficiency, a feeling of isolation and more seriously can result in accident (Webb, 1978).

1.4 Noise surveys

Many noise surveys have been conducted in many cities throughout the world. Most of these studies revealed that road traffic were typically the largest contributor to urban noise. A survey in Sweden showed that 79.5 per cent of all persons between 15 and 20 applying for jobs had hearing troubles caused by noise (Barrekette, 1974).

A study on a group of patients from exposed to occupational noise pollution suggested that the exposition to acoustic defilement during work activity might be considered as an etiological factor for development and progression of sensorineural hearing impairment, and more extensively for the occurrence of cardiovascular complication (Solerte *et al.*, 1991).

On the basis of a survey that has been done in to compare blood pressure in deaf-mute children and children with normal hearing, it was suggested that noise exposure is associated with higher systolic and diastolic blood pressure (Wu *et al.*, 1993).

Children attending kindergartens situated in areas with traffic noise >60 dB(A) had shown to have higher mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) and lower mean heart rate than children in quiet areas (Regecova & Kellerova, 1995). An overall dose-response relationship between noise exposure levels (<75dB (A), 76-80 dB(A), 81-85 dB(A), >86 dB(A) and mean serum lipid/lipoprotein levels was also reported for younger men only (Melamed *et al.*, 1997).

Significant association were found between noise and potential ischemic heart disease risk factors (IHD), including total triglycerides, platelet count, plasma viscosity, glucose (increase), and systolic and diastolic blood pressure (decrease) (Babisch *et al.*, 1993).

In a household environmental survey on exposure to noise in Palestine, it was indicated that 69.4% of households in the West Bank were seldomly exposed to noise, against 62.8% in Gaza Strip. The percentages of households that were sometimes exposed to noise were 18.5% in Gaza Strip and 14.3% in West Bank, whereas 16.9% of households in the Palestinian were very often exposed to noise. The survey also showed that traffic was the most important source of noise in the Palestinian area for 54.2% of households, whereas construction work was the most important source of noise 44.0% of households in the Gaza Strip and for 24.7% in West Bank (Palestinian Central Bureau of Statistics, 1998). This qualitative survey was based on a household using a special questionnaire only.

1.5 Measurement of noise pollution

The range of sound pressure encountered in noise control work is so wide that it is convenient to employ sound pressure level (SPL), a quantity that is proportional to the logarithm of the sound pressure. This is because a logarithmic scale compresses the range. By definition, the sound pressure level of sound waves having a sound pressure, is equal to $SPL = 20 \log_{10} (P/20)$ dB. Sound pressure level in decibels with reference to 20 micropascals. This reference has been adopted by international agreement (Harris, 1979). It approximates the minimum sound pressure that is audible to the normal young adult ear in the frequency range where the ear is most sensitive, while this reference ranging [$20*10^{-6}$ - $10*10^{8}$ N/M^2] which is equivalent to [0 - 140] in dB(A) (Harris, 1979).

Some of the measured quantities or parameters used for community noise measurements are listed below:

1. L_{eq} –a single noise level in dB(A) (L_{eq}) which, if constant, has the same hearing damage potential as varying noise level being measured. This quantity is important in machines.

2. L_{10} –that noise level in dB(A) exceeded 10% of the measured time.

3. L_{90} -that noise level in dB(A) exceeded 90% of the measured time.

4. L_N -the noise level in dB(A) exceeding N% of the measured time where N is from 1 to 99.

5. L_{NP} -the sound pressure level of the noise pollution is given by the following equation $L_{NP} = L_{eq} + L_{10} - L_{90}$ in dB(A) (Lord *et al.*, 1980; Stumpf, 1980).

1.6 Regulations of noise pollution

Regulations and standards of different types of noise pollution have been formulated by different organizations and institutions in the last 20 years, e.g., Occupational Safety and Health Act (OSHA), Housing and Urban Development (HUD), American National Standard Institute (ANSI), International Standard Organization (ISO), and others (Stumpf, 1980). Each organization has certain specifications to the physical quality to be measured and the techniques for the measurements. The regulations that relate to the type of noises being measured, e.g., OSHA is concerned with industrial noise pollution, HUD regulations with community noise, and ANSI 1969 put a scale of hearing impairment (Figure A.1) (Katz, 1985, Lord *et al.*, 1980; Stumpf, 1980).

1.7 Objectives of this study

No regulations concerning noise pollution have been yet formulated in Palestinian authority. In the West Bank, data on noise pollution and its association with auditory and non-auditory effects are lacking. Therefore, this work aimed to investigate the effects of noise pollution levels in three different areas of noise pollution , on hearing, arterial blood pressure, and pulse rate in school children residing in these areas.

Chapter 2

Methodology

2.1 Study population

The study population consisted of 480 school children (240 females, 240 males) aged 9-10 years, belonging to six schools located at three different localities (2 schools, 1 male and 1 female, at each locality). Eighty children were chosen randomly at each school. The three localities were the city of Nablus, with approximately 150,000 inhabitants, and crowded with traffic and factories; Tulkarem refugee camp, located one km east of Tulkarem, with approximately 30,000 inhabitants, situated at the Tulkarem - Nablus road; and Seida village, located 18 km north east of Tulkarem, with approximately 3,000 inhabitants, and represented a quiet rural area. The three locations were expected to have different noise pollution levels (Table A.2).

The children deemed eligible for this study were healthy and were not compelled to undergo the investigation. The children's health status was checked from medical records available in their schools. The same equipment and the same method for screening all of the participants were employed throughout this study.

2.2 Methods

Data collection at schools was carried out during morning hours (between 7:30 and 13:00), during the period from January to June 1999, all throughout the study. Measurements took twice for each case then mean was calculated.

2.2.1 Sound pressure level measurement

Sound pressure level (SPL) measurement was carried out in side class rooms using a logging sound level meter (Quest Technologies, U.S.A, model 2900 type 2), in (dB) units with an accuracy of ± 0.5 dB(A) at 25°C (Figure 2.1). The noise pollution level L_{NP}, the most common measurement, was then calculated using the equation:

$L_{NP} = L_{eq} + L_{10} - L_{90}$ (Diehl, 1973). The instrument responds to sound in approximately the same way as the human ear which gives objective reproduceable measurements of sound level. The sound signal is converted to an identical electrical signal by a high quality microphone. Since the signal is quite small, it must be amplified signal may pass through a weighting network (A, B, C, or D), in this study weighting network type A was used so the signal called dB(A). After additional amplification the signal will be high enough to drive the ammeter, and its root mean square (RMS) value has been determined in the RMS detector. The value read on the ammeter is the sound level in dB(A). Since the sound level meter is a precision instrument, provision is made to calibrate it for accurate results. Placing a portable acoustic calibrator (V) directly over the microphone does this. This calibrator is basically a miniature loud speaker giving a precisely defined sound pressure level to which the sound level meter can be adjusted (Figure 2.1).

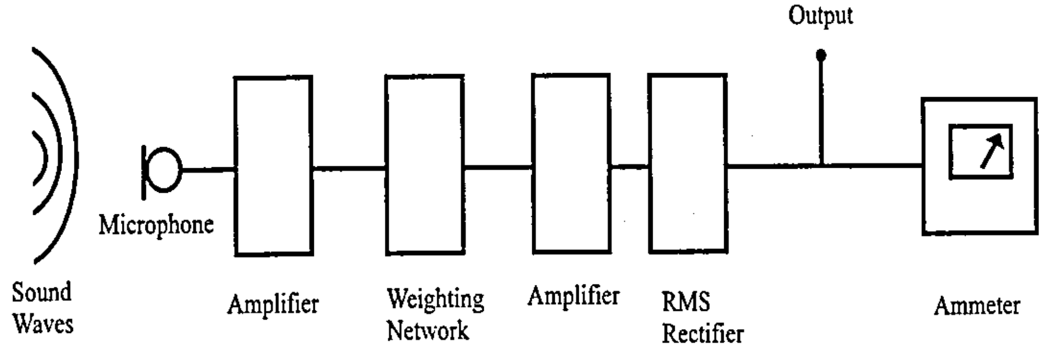

Figure 2.1 Block diagram for sound level meter.

The accuracy of the logging sound level meter used is ± 0.5dB(A) at 25°C and its precision is 0.1dB(A) (Manual Instruction for Sound level Meter; Diehl, 1973).

2.2.2Hearing threshold measurements

The response of auditory system (threshold of hearing) was measured for each child at different frequencies (125, 250, 500, 750, 1000, 1500, 2000, 3000, 4000, 6000, 8000 Hz) by AM 232 Manual Audiometer (Welch Allyn Inc., U.S.A) with accuracy ± 3%, at operating temperature 15°C to 40°C. The results of each left and right ear was recorded in an audiogram form (Figure 2.2).

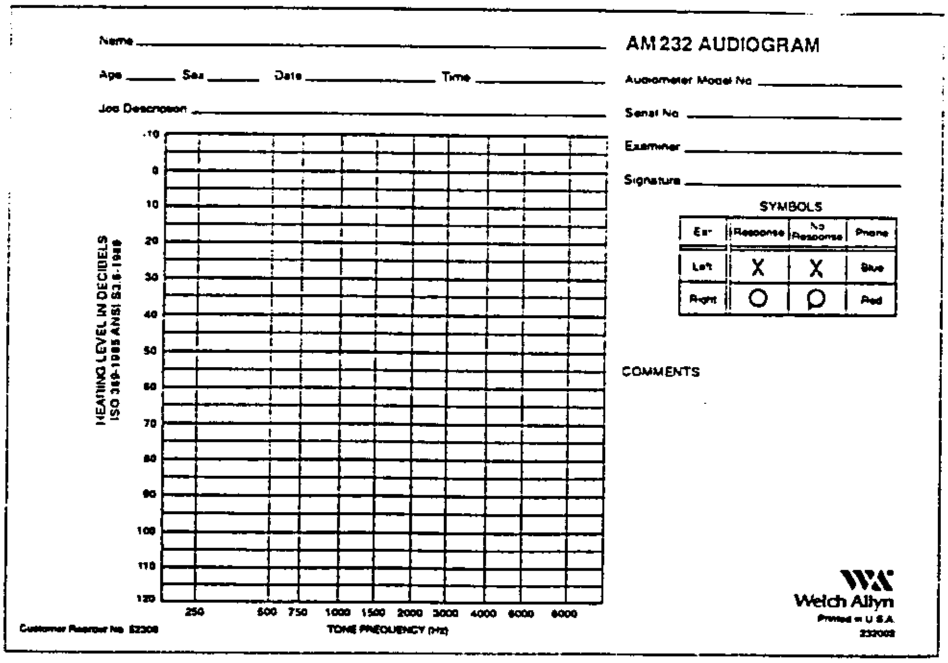

Figure 2.2 Audiogram showing scale of hearing impairment frequency in Hz

The hearing threshold shifts have been measured by choosing a child from each school shortly before experiencing noise pollution (pre-exposure) and during experiencing of two hours of relatively high noise pollution (post-exposure).

2.2.3 Arterial blood pressure and pulse rate measurements

The systolic and diastolic blood pressure and pulse rate were measured for each child by Automatic Digital Electronic Wrist Blood Pressure Monitor (Nihon Seimitsu Sokki Co., Japan model WS-300) with accuracy ± 3 mmHg cuff (pressure), and ±5% of reading pulse rate with operating temperature range of +10°C to +40°C.

2.2.4 Statistical analysis

The data were analysed using the SPSS program. Average values were expressed as group means ± SE. Analysis of variance (ANOVA) test was used to detect associations between dB(A) and pulse rate, arterial blood pressure and hearing threshold. In addition a Pearson correlation factor (R) was carried out to find the strength of the correlation between noise level and the dependent variables. To know the effect of noise pollution level in dB(A), and gender on pulse rate, arterial blood pressure and hearing threshold, a multiple comparison (Univariate Analysis of Variance) was carried out. $P < 0.05$ was considered statistically significant.

Chapter 3

Results

3.1 Noise pollution results

On the basis of sound level pressure measurements (Table 3.1), the three surveyed locations represented three different areas with different noise pollution level: quiet (Seida village) [78-85] dB(A), noisy (Nablus city) [92-96] dB(A), and very noisy (Tulkarem refugee Camp) [100-108] dB(A).

Table 3.1Noise pollution levels {dB(A)} at the different locations studies.

area	Location	School	Sex	dB level (L_{NP})
Quiet	Seida village	Seida boys school	male	77.8
		Seida girls school	female	85.2
Noisy	Nablus city	Tariq boys school	male	92.2
		Ali girls school	female	96.1
Very noisy	Tulkarm Refugees Camp	UNRWA boys school	male	100.4
		UNRWA girls school	female	108

3.2 Arterial blood pressure, pulse rate, and hearing threshold of ears in school children results

Arterial blood pressure (systolic and diastolic) values {mean ± standard error (SE)}, pulse rate, and hearing threshold of right and left ears for whole study groups are given in Table 3.2 and Table 3.3.

Table 3.2 Mean values (± SE) of blood pressure (SYS & DIAS), pulse rate (P.R), and hearing threshold for study population in relation to sex of children

dB level	Sex	Sys	Dias	H.R.	125 R	125 L	250 R	250 L	500 R	500 L	750 R	750 L	1000 R	1000 L	1500 R	1500 L	2000 R	2000 L	3000 R	3000 L	4000 R	4000 L	6000 R	6000 L	8000 R	8000 L
Quiet	Male	96.41 ±.87	60.57 ±.80	80.50 ±1.00	22.93 ±1.40	25.43 ±1.44	25.87 ±1.69	27.12 ±1.64	28.43 ±1.83	28.31 ±1.79	22.00 ±1.43	21.87 ±1.35	20.00 ±1.54	20.06 ±1.42	14.43 ±1.19	15.31 ±1.30	12.87 ±1.16	13.25 ±1.34	10.06 ±1.14	10.37 ±1.17	9.68 ±1.15	9.37 ±1.17	10.25 ±1.32	8.75 ±1.33	11.18 ±1.49	9.00 ±1.51
	Female	101.80 ± .83	66.48 ±.72	84.52 ±.95	25.43 ±.84	25.75 ±1.11	26.68 ±1.05	27.43 ±1.12	27.50 ±1.18	27.62 ±1.18	22.62 ±1.02	23.37 ±1.12	20.12 ±1.97	21.50 ±1.13	15.68 ±.88	17.12 ±1.00	13.93 ±.86	15.31 ±1.00	12.68 ±.85	12.31 ±.96	12.31 ±.90	11.18 ±.88	12.25 ±1.08	11.06 ±.93	12.31 ±1.07	11.81 ±.99
Noisy	Male	106.81 ±1.12	67.90 ±.93	89.67 ±1.65	29.75 ±1.45	25.68 ±1.43	29.37 ±1.44	26.12 ±1.59	30.25 ±1.41	27.93 ±1.59	26.43 ±1.42	24.37 +1.66	22.68 ±1.32	21.56 ±1.51	20.12 ±1.30	17.56 ±1.46	16.50 ±1.19	15.00 ±1.28	14.43 ±1.22	14.06 ±1.35	13.87 ±1.19	13.50 ±1.36	11.81 ±1.07	12.00 ±1.26	10.31 ±1.06	10.31 ±1.23
	Female	106.81 ±1.51	66.85 ±.92	90.18 ±1.66	35.25 ±1.26	28.87 ±1.74	37.12 ±1.70	33.81 ±2.10	38.43 ±1.96	36.43 ±2.37	36.06 ±1.91	33.50 +2.36	33.18 ±2.17	31.25 ±2.36	29.00 ±2.03	27.37 ±2.36	24.87 ±1.85	23.93 ±2.30	22.50 ±1.85	20.93 ±2.22	22.06 ±1.91	20.25 ±2.18	20.31 ±1.85	18.68 ±2.04	18.50 ±1.69	18.37 ±2.08
V. Noisy	Male	112.60 ±1.62	75.33 ±1.47	87.75 ±1.10	34.00 ±.88	31.50 ±1.10	38.62 ±1.00	37.25 ±1.26	39.50 ±1.08	37.81 ±1.32	36.31 ±1.09	34.93 +1.24	35.50 ±1.12	34.18 ±1.28	29.25 ±1.13	30.25 ±1.42	27.75 ±1.14	28.50 ±1.19	26.75 ±1.37	25.56 ±1.45	26.18 ±1.45	24.75 ±1.45	26.06 ±1.63	24.93 ±1.56	25.87 ±1.74	24.68 ±1.65
	Female	120.26 ±1.97	78.45 ±1.96	93.78 ±1.21	40.62 ±1.22	37.75 ±1.28	42.81 ±1.55	40.81 ±1.52	42.87 ±1.61	40.75 ±1.58	37.75 ±1.84	35.43 +1.88	38.00 ±1.89	35.31 ±1.91	31.18 ±1.73	29.12 ±1.80	31.12 ±1.78	28.75 ±1.82	26.37 ±2.00	24.93 ±1.74	26.31 ±2.02	24.25 ±1.83	24.87 ±1.97	23.31 ±1.74	24.56 ±1.97	23.43 ±1.77

Table 3.3 Mean values (±SE) of blood pressure, pulse rate, and hearing threshold for study populations in relation to children's places of residence

Residence	No.	SYS	DIAS	H.R.	125 R	125 L	250 R	250 L	500 R	500 L	750 R	750 L	1000 R	1000 L	1500 R	1500 L	2000 R	2000 L	3000 R	3000 L	4000 R	4000 L	6000R	6000 L	8000R	8000 L
City	160	106.81±.93	67.37 ±.65	89.93 ±1.17	32.50 ±.98	27.28 ±1.13	33.25 ±1.15	29.96 ±1.35	34.34 ±1.24	32.18 ±1.45	31.25 ±1.25	28.93 ±1.48	27.93 ±1.33	26.40 ±1.45	24.56 ±1.25	22.46 ±1.43	20.68 ±1.14	19.46 ±1.36	18.46 ±1.15	17.50 ±1.32	17.96± 1.17	16.87± 1.31	16.06± 1.12	15.34± 1.23	14.40± 1.04	14.34± 1.24
Village	160	99.10 ±.63	63.53 ±.58	82.51 ±.70	24.18 ±.82	25.59 ±.90	26.28 ±.99	27.28 ±.99	27.96 ±1.08	27.96 ±1.06	22.31 ±.88	22.62 ±.87	20.06 ±.91	20.78 ±.91	15.06 ±.74	16.21 ±.82	13.40 ±.72	14.28 ±.84	13.37 ±.71	11.34 ±.76	11.00± .73	10.28± .73	11.25± .85	9.90 ±.81	11.75± .91	10.40± .91
Camp	160	116.43±1.30	76.89 ±1.22	90.76 ±.85	37.31 ±.79	34.62 ±.88	40.71 ±.93	39.03 ±.99	41.18 ±.97	39.28 ±1.03	37.03 ±1.07	35.18 ±1.12	36.75 ±1.09	34.75 ±1.14	30.21 ±1.03	29.68 ±1.14	29.43 ±1.06	28.62 ±1.08	26.56 ±1.21	25.25 ±1.13	26.25± 1.24	24.50± 1.16	25.46± 1.27	24.12± 1.16	25.21± 1.31	24.06± 1.20

3.3 Relationship between sound levels and arterial blood pressure, pulse rate, and hearing threshold in school children

Strong positive correlations (Pearson Correlation Coefficient) were found between noise level in dB(A) and dependent variables (systolic pressure, diastolic pressure, pulse rate, and hearing threshold) at the following frequencies 125RL, 250RL, 500RL, 750RL, 1000RL, 1500RL, 2000RL, 3000RL, 4000RL, 6000RL, and 8000RL (Table3.4).

Table 3.4 Pearson correlation coefficients between sound level in dB(A) and arterial blood pressure(SYS., DIAS), pulse rate, and hearing threshold at different frequencies in schools children.

Independent	Dependent	Pearson correlation coefficient
dB	SYS	0.521**
dB	DIAS	0.440**
dB	P.R.	0.440**
dB	125 R	0.097*
dB	125 L	0.311**
dB	250 R	0.432**
dB	250 L	0.334**
dB	500 R	0.369**
dB	500 L	0.299**
dB	750 R	0.371**
dB	750 L	0.339**
dB	1000 R	0.413**
dB	1000 L	0.374**
dB	1500 R	0.389**
dB	1500 L	0.365**
dB	2000 R	0.445**
dB	2000 L	0.398**
dB	3000 R	0.402**
dB	3000 L	0.375**
dB	4000 R	0.420**
dB	4000 L	0.374**
dB	6000 R	0.392**
dB	6000 L	0.368**
dB	8000 R	0.364**
dB	8000 L	0.353**

SYS: Systolic blood pressure (mmHg); Dias: Diastolic blood pressure (mmHg); P.R: Pulse rate (beats/min); R: Right ear; and L: Left ear. *: Significant (P<0.05), **: highly significant (P<0.01).

A significant effect for noise level in dB(A) on each dependent variables was detected in this study by ANOVA test (F-test) Table 3.5. The effect of sound noise level in dB(A) reacting with sex and systolic, diastolic, pulse rate and hearing threshold is shown in Table 3.6. Noise level dB(A) and sex did not significantly affect pulse rate, and hearing threshold at frequencies 125RL, 250RL, 4000L.

Table 3.5 F-test values between dB and arterial blood pressure, pulse rate, and hearing threshold.

ANOVA		
Variables	F	Sig
dB* SYS	78.29	0.000
dB* DIAS	63.74	0.000
dB* P.R.	24.45	0.000
dB* 125 R	60.71	0.000
dB* 125 L	24.46	0.000
dB* 250 R	50.43	0.000
dB* 250 L	30.57	0.000
dB* 500 R	36.43	0.000
dB* 500 L	23.16	0.000
dB* 750 R	49.14	0.000
dB* 750 L	28.63	0.000
dB* 1000 R	57.06	0.000
dB* 1000 L	35.88	0.000
dB* 1500 R	56.83	0.000
dB* 1500 L	34.70	0.000
dB* 2000 R	67.55	0.000
dB* 2000 L	43.43	0.000
dB* 3000 R	53.85	0.000
dB* 3000 L	40.90	0.000
dB* 4000 R	51.97	0.000
dB* 4000 L	42.57	0.000
dB* 6000 R	44.46	0.000
dB* 6000 L	44.28	0.000
dB* 8000 R	42.63	0.000
dB* 8000 L	75.08	0.000

Degrees of freedom = 2 for all tests.

Table3.6 F-test values between dB and sex and arterial blood pressure, pulse rate, and hearing threshold.

ANOVA		
Variables	F	Sig
dB * sex * SYS	4.023	0.019
dB * sex * DIAS	4.133	0.017
dB * sex * P.R.	2.314	0.100
dB * sex * 125 R	1.565	0.210
dB * sex * 125 L	2.339	0.098
dB * sex * 250 R	2.911	0.055
dB * sex * 250 L	2.755	0.065
dB * sex * 500 R	4.343	0.014
dB * sex * 500 L	3.795	0.023
dB * sex * 750 R	5.537	0.004
dB * sex * 750 L	4.039	0.018
dB * sex * 1000 R	6.049	0.003
dB * sex * 1000 L	4.283	0.014
dB * sex * 1500 R	4.309	0.014
dB * sex * 1500 L	6.119	0.002
dB * sex * 2000 R	3.662	0.026
dB * sex * 2000 L	4.324	0.014
dB * sex * 3000 R	4.265	0.015
dB * sex * 3000 L	3.06	0.048
dB * sex * 4000 R	3.797	0.023
dB * sex * 4000 L	2.883	0.057
dB * sex * 6000 R	5.181	0.006
dB * sex * 6000 L	3.719	0.025
dB * sex * 8000 R	5.098	0.006
dB * sex * 8000 L	4.349	0.013

Degrees of freedom = 2 for all tests.

Comparison of the group mean arterial blood pressure and pulse rate values of children attending schools in areas with different noise levels in dB(A) showed significantly higher values of systolic and diastolic arterial blood pressure, pulse rate, and hearing threshold in noisy or very noisy environment than in quiet environment (Table 3.2 and Table 3.3). The mean systolic blood pressure (SBP) and pulse rate values were even significantly higher in very noisy than in noisy areas (Figure 3.1). The sound level pressure dB(A) in schools seems to have less bearing on diastolic blood pressure (DBP) values, but was significantly associated with increased SBP reading. Similarly, the behavior of SBP, and mean pulse rate values tended to increase with increasing noise level pressure recorded at schools. Also mean hearing levels tended to increase with increasing noise level dB(A), i.e., hearing loss was increasing with increasing noise level dB(A).

The behavior of the mean systolic and diastolic blood pressure is consistent. A significant increase in arterial blood pressure was associated with higher noise pollution levels (Figure 3.1). The mean SBP and DBP for the two sexes were correlated positively with the noise pollution level (R= 0.521 and 0.440, respectively). The analysis of variance of data on systolic and diastolic blood pressure related to the noise level dB(A) are given in Tables 3.7 and 3.8

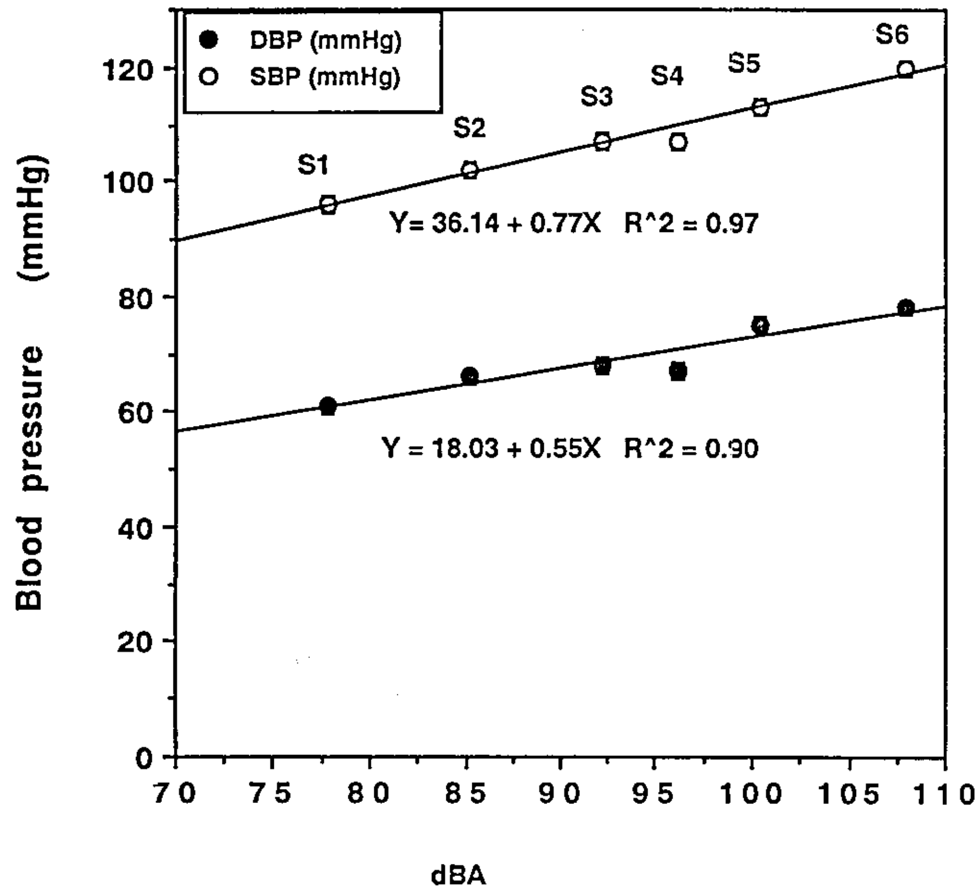

Fig. 3.1 Values of average of systolic and diastolic blood pressure according to noise pollution level.

DBP: Diastolic blood pressure. SBP: Systolic blood pressure

Table3.7 Mean values of basic systolic blood pressure (SBP) related to noise level

Noise level (dB)	sex	Standard Error	df	F - test	mean ± SE (mmHg)	Significant	%95confidence interval	
							Lower	Upper
Quiet	male	1.387	2	4.02	0.87 ±96.41	0.019	10.43-	4.98-
	female	1.387	2	4.02	0.83 ± 101.80	0.019	20.05-	14.59-
Noisy	male	1.387	2	4.02	1.12±106.81	0.019	4.98	10.43
	female	1.387	2	4.02	1.51 ± 106.81	0.019	12.34-	6.89-
Very noisy	male	1.387	2	4.02	1.62± 112.6	0.019	14.59	20.05
	female	1.387	2	4.02	1.97 ± 120.26	0.019	6.89	12.34

Table3.8 Mean values of basic diastolic blood pressure (DBP) related to noise level.

Noise level (dB)	sex	Standard Error	df	F- test	Mean ± SE (mmHg)	significant	%95confidence interval	
							Lower	Upper
Quiet	male	1.219	2	4.133	0.80 ±60.57	0.017	6.23-	1.44-
	female	1.219	2	4.133	0.72 ± 66.48	0.017	15.75-	10.96-
Noisy	male	1.219	2	4.133	0.93 ± 67.90	0.017	1.44	6.23
	female	1.219	2	4.133	0.92 ± 66.85	0.017	11.91-	7.12-
Very noisy	male	1.219	2	4.133	1.47 ± 75.33	0.017	1096	15.75
	female	1.219	2	4.133	1.96 ± 78.45	0.017	7.12	11.91

In consistent to the behavior of arterial blood pressure, mean pulse rate values for the two sexes tended to increase with increasing noise level (Table 3.9, Figure 3.2). The positive correlation coefficient between the pulse rate and the noise pollution level was found (R= 0.440).

Table 3.9 Mean values of basic pulse rate in school children related to noise level.

Noise level (dB)	Sex	Standard Error	df	F - test	mean ± SE (beats / min)	Significant	%95confidence interval	
							Lower	Upper
Quiet	Male	1.30	2	2.31	1.00± 80.50	0.10	9.97-	4.86-
	Female	1.30	2	2.31	0.95 ± 84.52	0.10	10.81-	5.70-
Noisy	Male	1.30	2	2.31	1.65 ± 89.6	0.10	4.86	9.97
	female	1.30	2	2.31	1.66 ± 90.18	0.10	3.39-	1.71
Very noisy	male	1.30	2	2.31	1.10 ± 87.75	0.10	5.70	10.81
	female	1.30	2	2.31	1.21 ± 93.78	0.10	1.71-	3.39

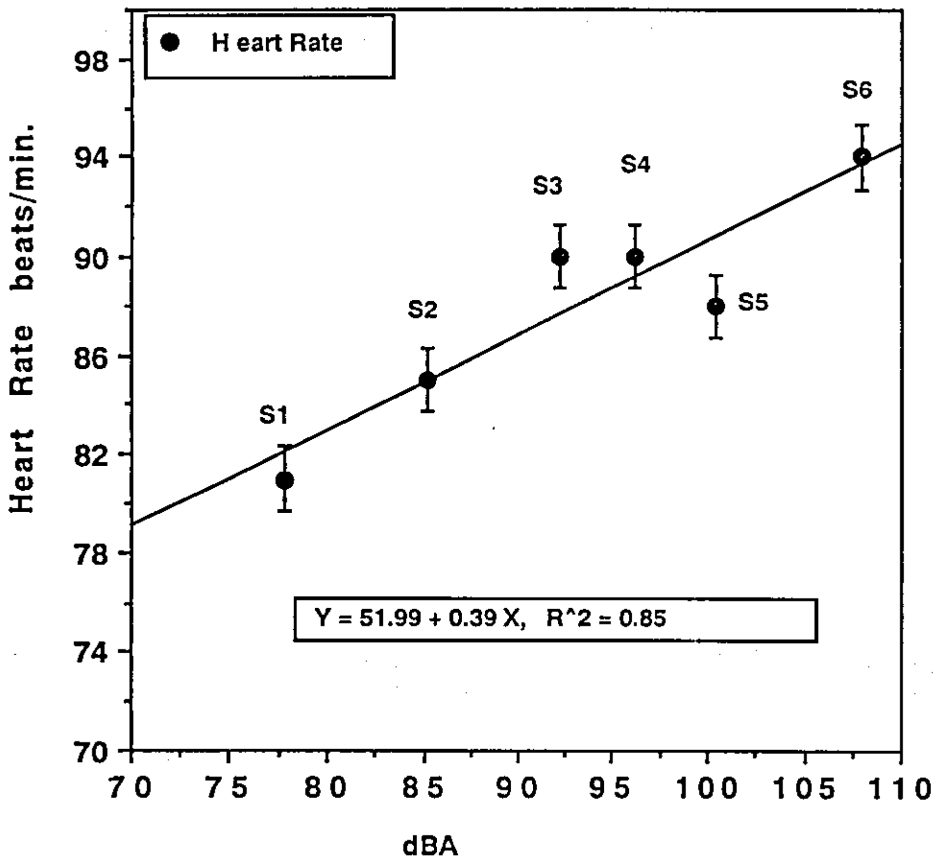

Fig.3.2 Values of average mean heart rate of children according to noise level in different schools as follows:
S1: Selda boys, S2: Selda girls, S3: Tariq boy,
S4: Ali girls, S5: UNDP boys, S6: UNDP girls.

The hearing threshold levels of different frequencies correlated positively with the noise pollution level (R = 0.114 to 0.267; $p < 0.05$). The hearing threshold levels of left and right ears for different samples for the two sexes are plotted as a function of frequency in Figure 3.3. The recorded data are shown in Table 3.1

Figures 3.4 - 3.9 show the results of hearing threshold shifts in the right and left ears in different locations shortly before experiencing noise pollution (pre-exposure) and during experiencing of two hours of relatively high noise pollution (post-exposure). The recorded data are shown in Table 3.10

Table 3.10 Hearing threshold before and during experienced noise pollution.

	Tariq Primary School for Boys				Ali Primary School for Girls				UNDP Primary School for Boys				UNDP Primary School for Girls				Seida Secondary School for Boys				Seida Secondary School for Girls			
Hz	R		L		R		L		R		L		R		L		R		L		R		L	
Frequency	B	D	B	D	B	D	B	D	B	D	B	D	B	D	B	D	B	D	B	D	B	D	B	D
125	30	60	25	40	30	35	30	50	30	50	45	40	35	50	35	30	25	30	30	40	20	25	25	25
250	30	60	30	40	35	40	50	55	30	55	40	35	35	45	25	30	30	35	30	45	20	30	25	30
500	35	60	35	40	35	50	45	60	40	55	30	35	35	45	25	30	40	40	35	45	25	30	30	35
750	30	50	30	35	35	50	45	55	35	40	35	40	30	40	30	25	35	35	40	40	25	30	25	30
1000	30	55	30	30	35	50	45	50	30	40	30	30	30	40	20	25	25	35	35	40	20	25	20	25
1500	25	55	25	25	40	50	40	50	25	35	25	30	25	25	25	25	25	20	35	35	15	20	15	20
2000	20	50	20	20	30	40	30	35	15	30	10	25	15	25	15	25	15	15	30	35	10	15	15	15
3000	20	30	20	20	30	40	30	30	15	25	10	25	15	25	15	20	10	15	25	10	10	15	15	15
4000	25	30	30	20	25	40	25	30	10	20	10	25	20	25	15	20	10	10	20	10	5	15	10	15
6000	25	25	20	20	25	35	25	30	10	25	10	35	20	25	15	25	10	20	20	25	5	20	5	20
8000	25	25	15	20	25	30	25	30	10	25	5	35	20	25	15	25	5	20	20	25	5	20	5	20

R: right ear; L: left ear; B: before exposure to noise pollution; D: during exposure to noise pollution.

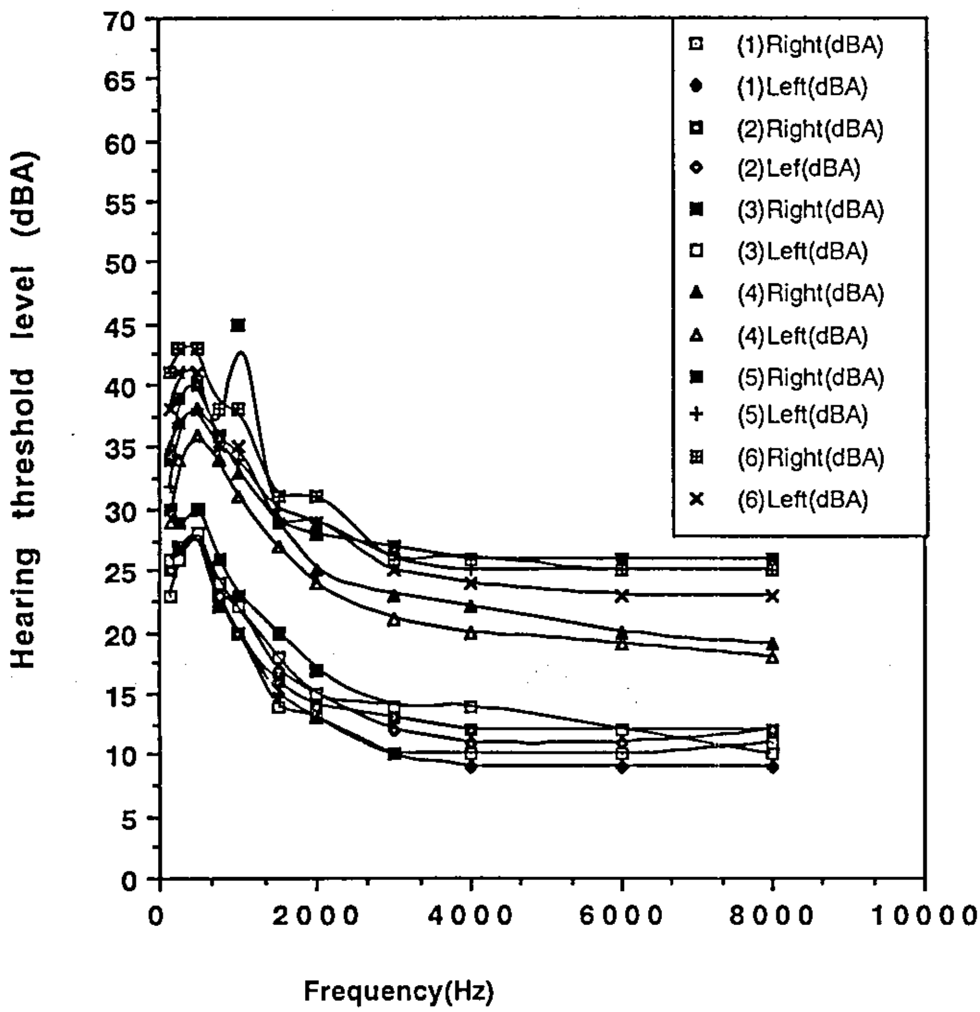

Fig. 3.3 Hearing threshold level of left and right ears for the different schools of the two sexes as a function of frequency.

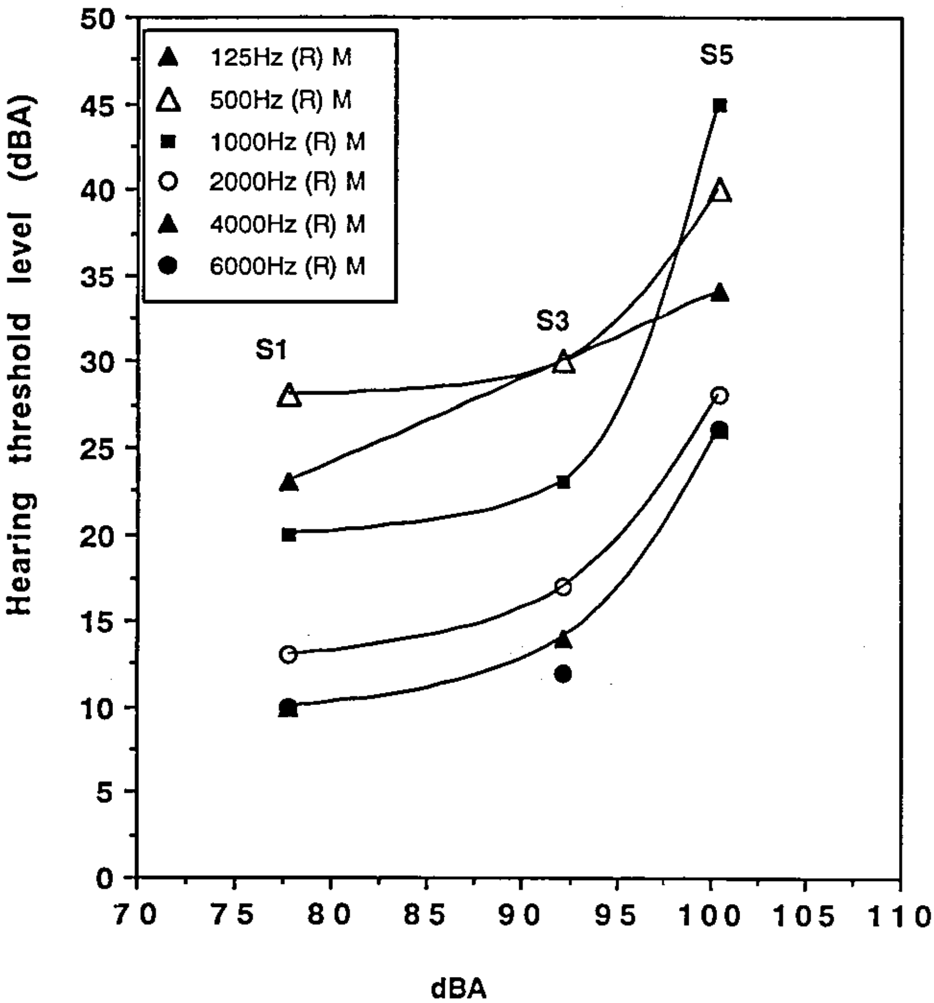

Fig. 3.4 Hearing threshold shifts in the right ear during experienced noise for male schools.

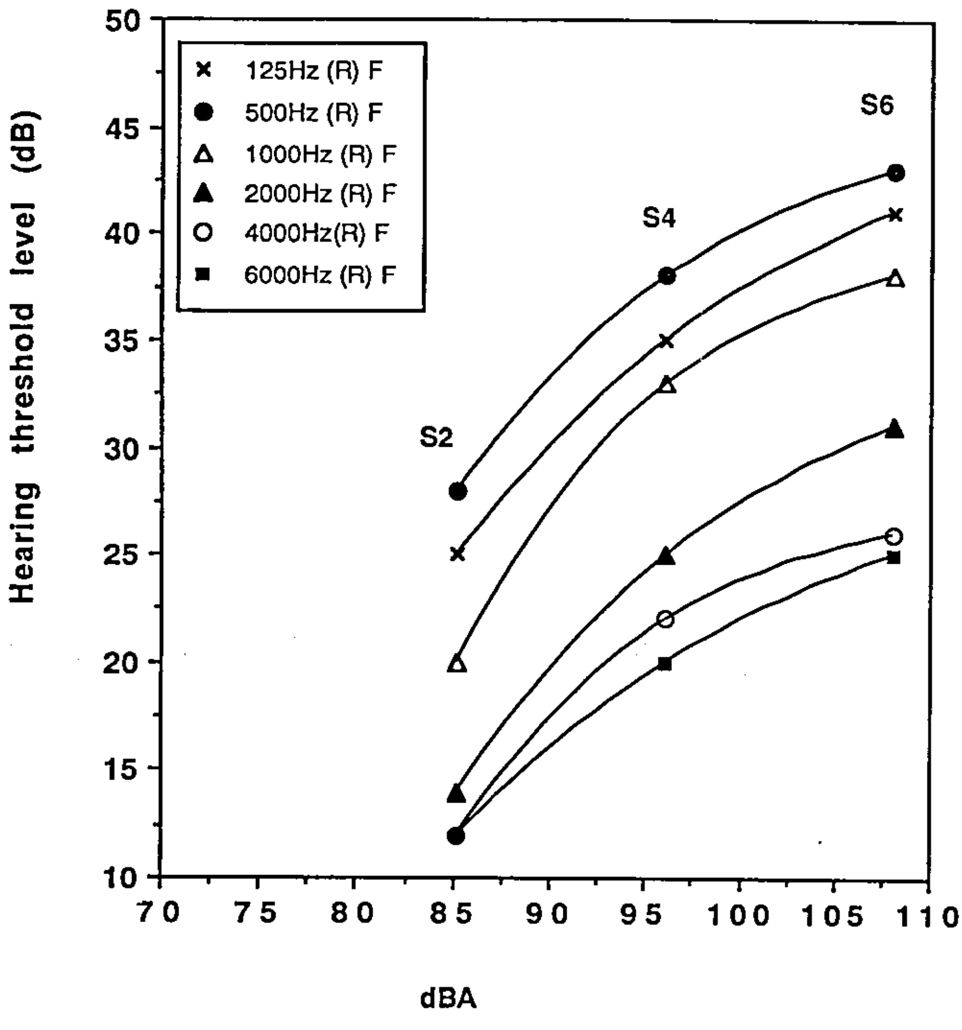

Fig. 3.5 Hearing threshold shifts in the right ear during experienced noise for female schools.

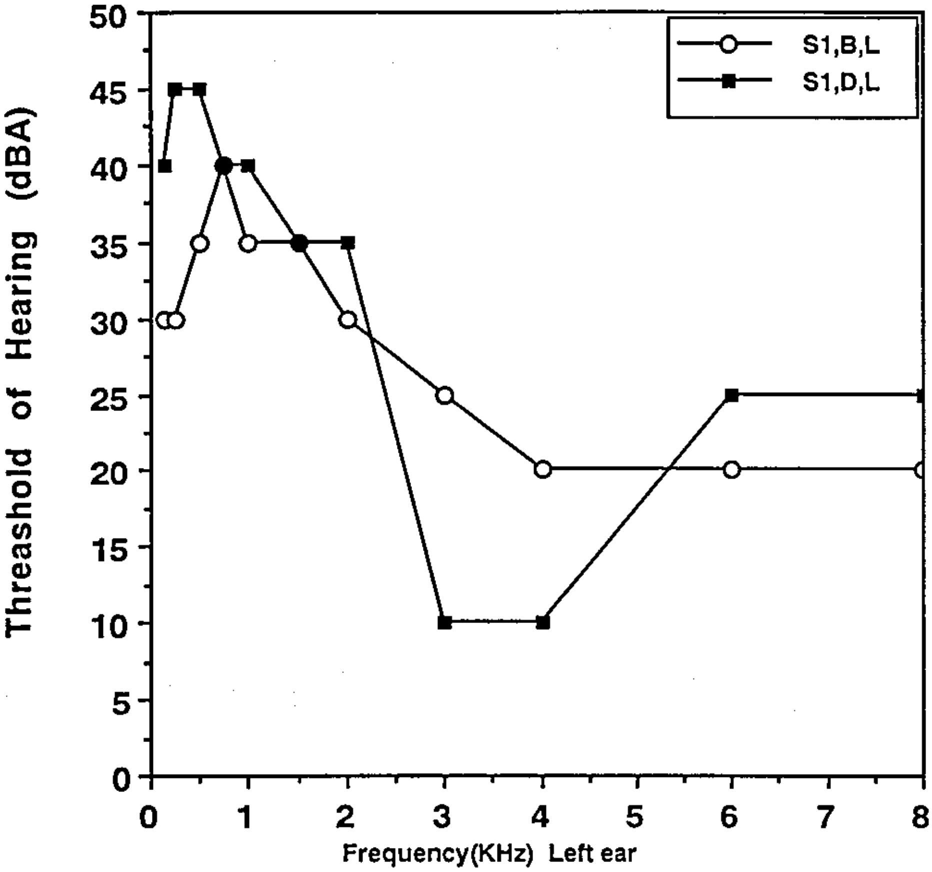

Fig. 3.6 Example of a noise induced temporary threshold shift experienced by an 9-year old before and during noise exposure in seida school.
S1: Seida boys school. B : Before. L : Left ear
D : During.

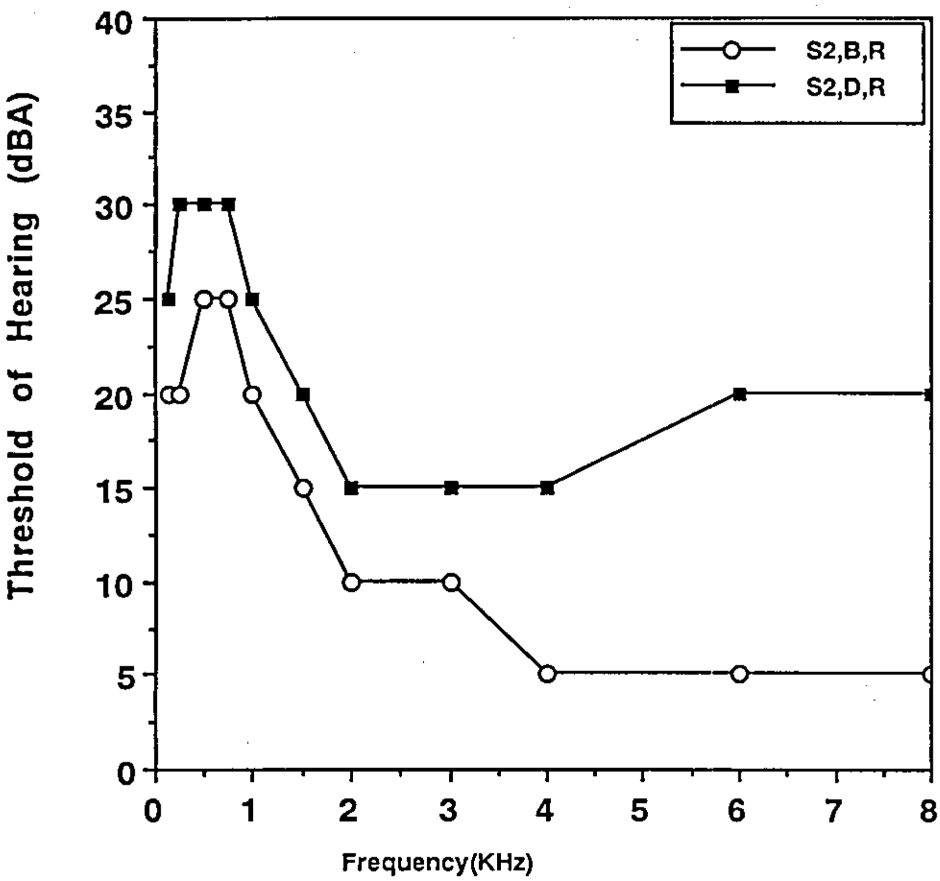

Fig. 3.7. Example of a noise induced temporary threshold shift experienced by an 9-year old before (B) and during (D) noise exposure in Selda. S2: Selda girls school. R: Right ear

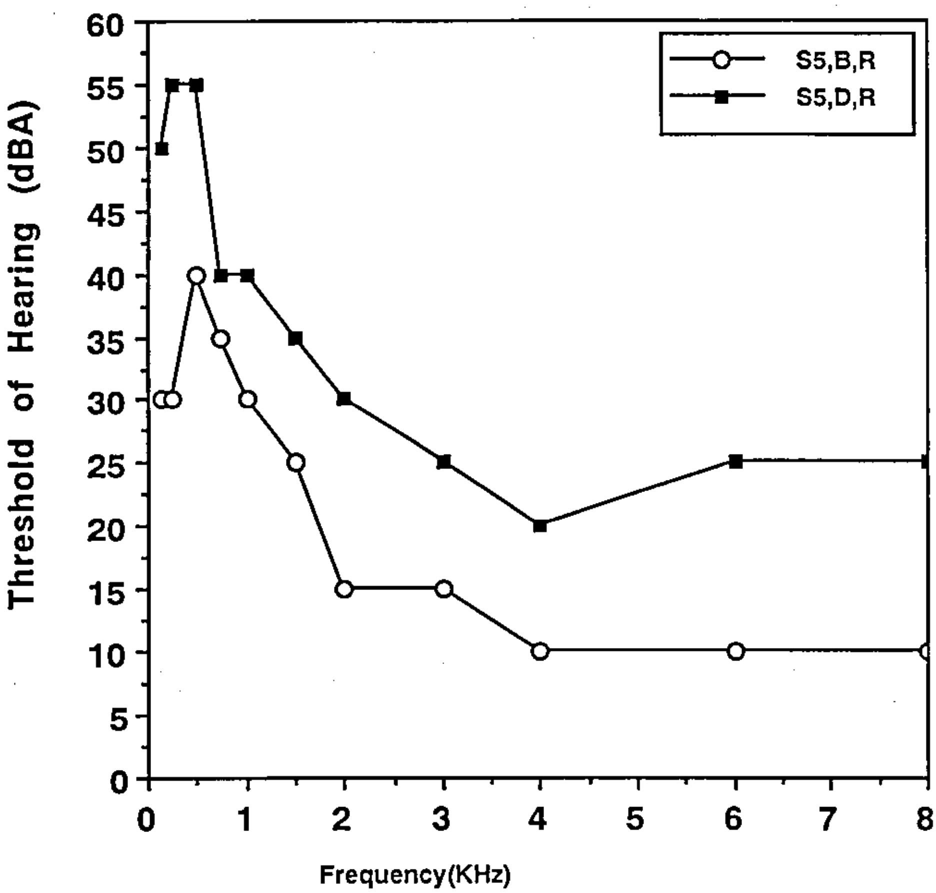

Fig.3.8 Example of a noise induced temporary threshold shift experienced by an 9-year old before (B) and during (D) noise exposure in camp. S5: UNDP boys school. R: Right ear.

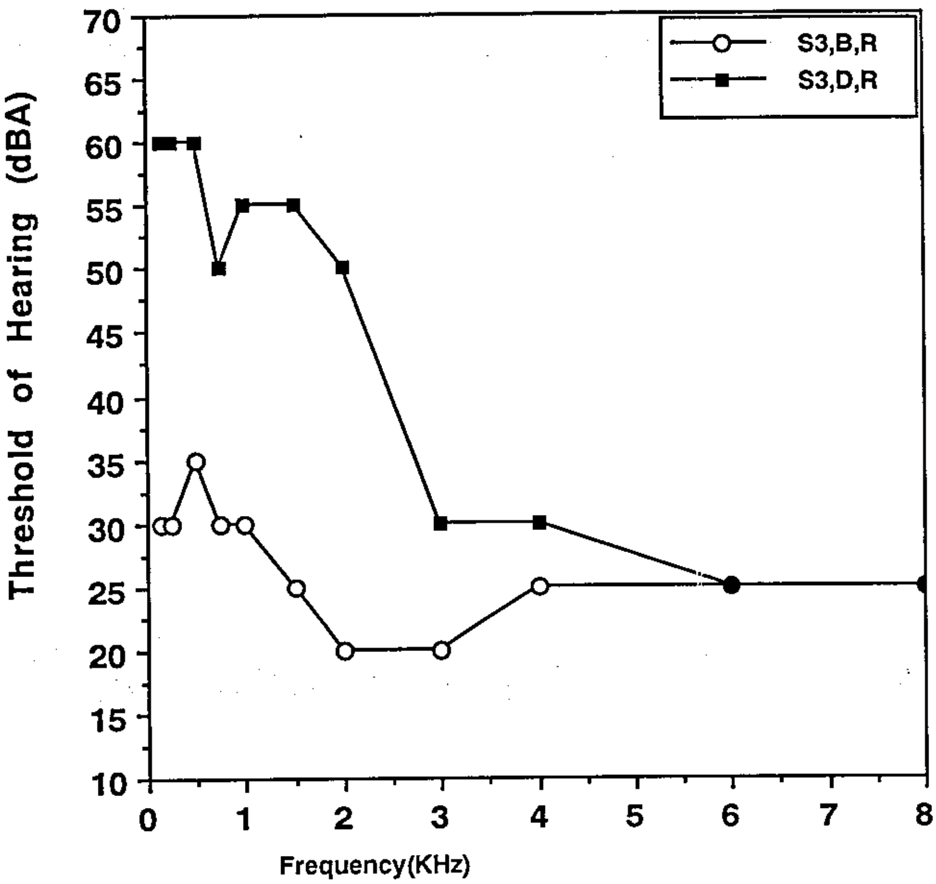

Fig.3.9 Example of a noise induced temporary threshold shift experienced by an 9-year old before (B) and during (D) noise exposure in Nablus city. S3: Tariq primary school for boys. R: Right ear.

Chapter 4

Discussion

In this work, the hearing threshold levels of different frequencies correlated positively with the noise pollution levels. In addition, our study showed that the hearing threshold shifts in the right and left ears shortly before experiencing noise pollution (pre-exposure) and during experiencing of two hours of relatively high noise pollution (post exposure). For example the shift difference in hearing threshold between pre-exposure and during experiencing relatively high noise pollution (post exposure) was 15 dB(A). Previous studies (Patrick, 1977), showed 10 dB(A) shift difference in hearing threshold between pre-exposure and postexposure by an 18-year old man.

If the ear is subjected to a noise pressure, a reflex action occurs which tightens muscles and reduced the sensitivity of the ear to low and middle frequencies by stifftening up the mechanical action of the middle ears, which causes the shift in the hearing threshold (Harris, 1979). Moreover there is a gradual deterioration of the cells in the organ of corti due to excessive overexposure to noise (Harris, 1979). In the most cases of hearing loss, there is a gradual shifting of the threshold of hearing due to reported exposure to noise, such as children exposed to high noise levels over a span of several years during their study in the noisy school areas (Harris, 1979).

Hearing threshold level of left and right ears for the different schools of the two sexes as a function of frequency in our study shows little difference between male and female (Figure 3.3), this result because elevation of noise pollution levels in female schools than in male schools. Studies of hearing loss seem to indicate that female retain better hearing sensitivity than male fowling essentially similar noise exposures (Harris, 1979).

In the current study the behavior of the arterial blood pressure (systolic and diastolic) for the two sexes showed a positive increase with the noise pollution level. The association between the urban traffic noise and blood pressure in preschool children have been investigated. The measurements showed that the behaviors of mean blood pressure increase with the higher traffic noise levels (Regecova and Kellerova, 1995). Another study showed that the noise exposure is associated with higher systolic and diastolic blood pressure (Wu *et al* ., 1993). Another study showed that industrial noise exposure is associated with higher blood pressure and pulse rates in men under 45 years old, but the effect on blood pressure appears to diminish considerably with age, Greens have studied the association between the industrial noise exposure and pulse rate. They found that the pulse rate was 2.7 beats per minute higher at the higher noise level (Green *et al.*, 1991).

In this study, the behavior of pulse rate for the two sexes showed a positive increase with higher noise pollution levels. The pulse rate was 8 beats per minute higher at the higher noise level. The changes in the diameter of blood vessels in response to noise pollution will increase the systolic and diastolic blood pressure (Harris, 1979). In general, high noise pollution level seems to increase the stress reaction that elevates blood pressure. This process will increase cardiac oxygen demand and causes an increase in the pulse rate, a diagrammatic presentation of these concepts is shown as follows:

Noise→stress reaction→ blood pressure→damage arterial wall
↓
Cardiac oxygen demand→elevated heart rate→heart attack (Harris, 1979).

A part from these physical changes, noise can cause psychological disturbances, the children become irritable and resentful against the cause of noise (Harris, 1979). In several tests it has been established that high noise levels can seriously affect productivity and efficiency and that fewer mistakes in the classes are made when noise levels are reduced. When this occurs it is a direct result of mental fatigue caused by noise which makes children to be absenteeism and disagreeable (Harris, 1979).

There are some very complex effects on memory, broadly, interference between memory for one event and that for another may be increased by noise (Harris, 1979).

In conclusion, the results of the present study showed that exposure to high noise level is associated with higher systolic and diastolic blood pressure, pulse rate, and hearing threshold shift for the two genders in primary school children.

Many things can be done to relieve the noise pollution problem in the pollutant schools. Some of these are quieting the noise sources, putting barriers or allowing enough spaces between schools buildings and noise sources, planting trees, following safety and health regulations, decreasing the number of pupils in the class room and school specially for the female schools because there are more sensitive for noise pollution exposure. However, further work can be done to support this study and encourage the authorities to set up ordinances and legislation to relieve the noise exposure to the blood pressure, pulse rate, and hearing threshold on the workers.

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Appendix A

Table A.1 OSHA'S Table of Permissible limit (PEL) for Noise

Time exposure Permitted (hr)	A-weighted sound level dB(A)	Time exposure Permitted (hr)	A-weighted sound level dB(A)
32	80	1.3	104
27.9	81	1.0	105
24.3	82	0.87	106
21.1	83	0.76	107
18.4	84	0.66	108
16.0	85	0.57	109
13.9	86	0.50	110
12.1	87	0.44	111
10.6	88	0.38	112
9.2	89	0.33	113
8.0	90	0.29	114
7.0	91	0.25	115
6.2	92	0.22	116
5.3	93	0.19	117
4.6	94	0.16	118
4.0	95	0.14	119
3.5	96	0.125	120
3.0	97	0.110	121
2.6	98	0.095	122
2.3	99	0.082	123
2.0	100	0.072	124
1.7	101	0.063	125
1.5	102	0.054	126
1.4	103	0.047	127

Source: Code of Federal Regulation 29 CFR 1910.95. (Environmental Control and Noise)

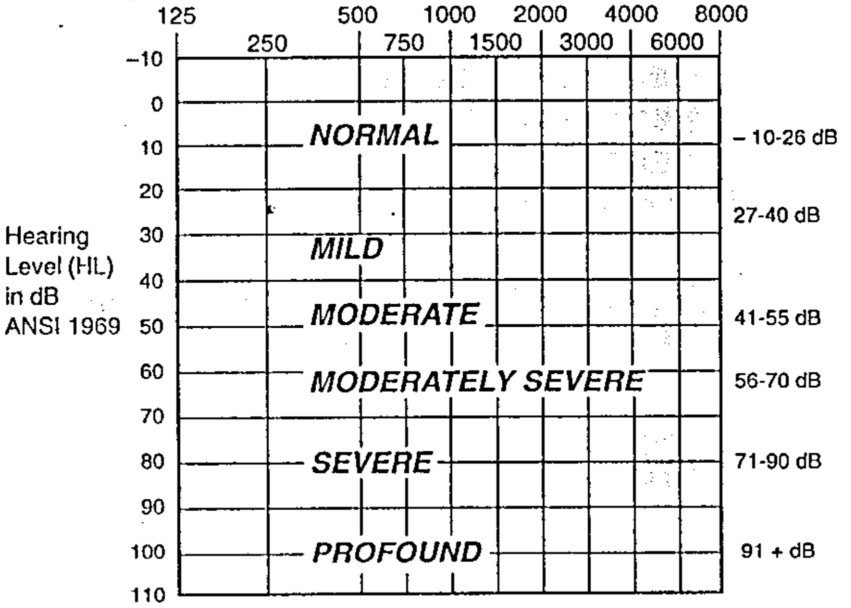
Table A.2 Description of schools environment.

School name	Location	Area of the school	No. of Classrooms	Average No. of pupils in each classroom	Trees and wall in the school
Seida Primary School for Boys	Beside the main street in Seida village	5000m^2	13	27	1.5m high wall and some trees
Seida Primary School for Girls	Beside the main street in Seida village	3500m^2	12	30	1.5m high wall and some trees
Tariq Primary School for Boys	Beside Nablus- Asqar street / Nablus city	900m^2	8	32	No trees, surrounded with market
Ali Primary School for Girls	Beside Al-Ma'moon street / Nablus city	1700m^2	10	41	No trees, 1.5m high wall
Tulkarem Camp Primary School for Boys	Beside Tulkarm-Nablus street / Tulkarm city	2000m^2	18	41	No trees, 1.5m high wall
Tulkarem Camp Primary School for Girls	BesideTulkarm-Nablus street / Tulkarm city	2500m^2	18	42	No trees, 1.5m high wall

Figure A.1 Scale of hearing impairment at different frequencies

Threshold Audiometry

Audiogram Showing
*Scale of Hearing Impairment**
Frequency in Hz



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Threshold Audiometry

Welch Allyn

بسم الله الرحمن الرحيم

تأثير الضوضاء على ضغط الدم، نبض القلب، ودرجة السمع عند طلاب المدارس

حسن راشد حسن عبد الرازق

إشراف

بروفيسور د. محمد سليم اشتية و د. عصام راشد عبد الرازق

الملخص

أظهرت هذه الدراسة العلاقة بين مستوى التلوث الضوضائي و ضغط الدم (الانقباضي و الانبساطي)، نبض القلب، ودرجة السمع لدى طلاب المدارس. ولقد تم اختيار المدارس عشوائيا" لتمثل ثلاث مناطق حسب مستوى التلوث الضوضائي، الهادئة (قرية صيدا، وكان معدل مستوى الضجيج 77.8-85.2 dB)، المزعجة (مدينة نابلس، وكان معدل مستوى الضجيج 92.2 - 96.1 dB)، والمزعجة جدا" (مخيم طولكرم وكان معدل مستوى الضجيج 100.4 -108 dB).

وجد معامل الارتباط قوي بين مستوى التلوث الضوضائي وضغط الدم الانقباضي والانبساطي، نبض القلب، ودرجة السمع على ذبذبات مختلفة. معدل ضغط الدم الانقباضي والانبساطي يرتبط بعلاقة طردية مع مستوى التلوث الضوضائي وكان معامل الارتباط بينهما على التوالي (R-0.521، و 0.440)، وكذلك كانت العلاقة طردية بين مستوى التلوث الضوضائي و معدل درجة السمع على ذبذبات مختلفة حيث تراوح معامل الارتباط R بين (0.114 إلى 0.267) باعتبار قيمة P<0.05.