An-Najah National University
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Effects of Occupational Noise Exposure on Blood Pressure, Pulse Rate, and Hearing Threshold Levels of Workers in Selected Industrial Plants in Jenin City, Palestine.

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Dedication

This thesis is dedicated to the memory of
My parents,
family, brothers, sisters, my wife,
and children,
with love and respect

Acknowledgement

I am very grateful to my supervisors Dr. Issam Rashid Abdel-Raziq and Dr. Zaid N. Qamhieh for their efforts and guidance throughout the entire research.

Special thanks to plant managers, owners, and to the workers of industrial plants for their help and patience.

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threshold levels) at the following frequencies 0.5KHz, 1 KHz, 2 KHz, 4 KHz, 6 KHz, and 8 KHz

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List of Abbreviations

dB	Decibel (unit of sound level using a logarithmic scale)
dB(A)	Decibel, by the A-weighted
DBP	Diastolic blood pressure
Hz	Hertz (unit of frequencies)
Leq	The equivalent noise level
OSHA	The Occupational Safety and Health Act
Pa	Pascal (unit of pressure
P	Pressure
P.R	Pulse rate
SE	Standard error
SBP	Systolic blood pressure
SPL	Sound Pressure Level
T-Test	A statistical test of the null hypothesis
P-value	Significance Level

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Abstract

This study reports the relationship between occupational noise level with arterial blood pressure (systolic and diastolic), pulse rate, and hearing threshold levels for workers in industrial plants in Jenin region. Accurate measurements for the noise levels were performed. The noise level lies between (78.2-98.5) decibels. Then Random sample of 15 plants were chosen to represent the different noise levels. The blood pressure, pulse rate, and hearing threshold levels at different frequencies were measured before and after exposure to noise for six to eight hours. Strong positive correlation (Pearson Correlation Coefficient) was found for most of the measured variables. The systolic blood pressure mean for the experimental sample is increased by 4.5 mmHg, while the diastolic blood pressure mean is increased by 5.1 mmHg, the pulse rate mean is increased by 9.1 beats/minute. The hearing threshold levels also shows a decrease mean of (1.2 to 5.8) decibels.

Chapter One

Introduction

1.1 Objectives of this study

The aim of this study is to find out the possible relation between the occupational noise exposure and arterial blood pressure, pulse rate, and hearing thresholds for the plants workers in Jenin city. This study also will help to determine the status of noise pollution since in the Palestinian territories, data on noise pollution and its effects on the diverse aspects of health are a few.

In developed countries, the problem of side effects of noise pollution studied in scientific ways. Knowing negative effects of noise promotes peoples with power to take actions to decrease or suppress noise. Media inform people to become conscious and aware of the probable consequences of noise. Therefore, laws and legislations have been adopted to recognize, protect, and combat all the society from the dangers of noise. Workers (the most exposed part to noise due to work setting) now have enough information about the noise effects and aware of there rights to work in healthy places. Governmental departments watch and observe the commitment of laws, and publish recommendations for the safety of peoples. The Occupational Safety and Health Administration (OSHA) in the U.S., for example created in 1971. Its mission is to prevent work-related injuries, illnesses, and deaths among workers " OSHA's mission is to assure the safety and health of America's workers by setting and enforcing standards; providing training, outreach, and education; establishing partnerships; and encouraging continual improvement in workplace safety and health" (OSHA, 2004). Since the agency establishment (OSHA), occupational deaths have been cut by 62% and injuries have declined by 42%.

In developing countries, the picture is different, the situation is worst; the awareness of noise effects is low, weak legislation, and if there is the commitment and interest of them is powerless. As a result, the negative effects are bigger. More work has to be done to explain and illuminate this issue; workers present a wide portion of society, and probably the most subjected to noise. So they deserve more care and interest to maintain their well health as possible.

In Palestine the political conditions controls almost all the phases of, life, this reflects almost negatively on everything. Legislation is found but neglected largely, awareness is missed and there is little care. This can be overcome by doing more researches and transcribe basic information to them and to the people in the command.

Palestine is not a considerable industrialized country; it is a small country in which small plants and factories are found. Noise causes a lot of adverse effects. To understand and control these effects there is a need to recognize the exact situation. There is a lack of available information in Palestine regarding the noise issue. More information is needed regarding the conditions workers subject to. Such as the level of sound, hours of work, environment of work, temperature of work, ventilation, heavy metals, harmful chemicals, noise, and other factors of work. Awareness of the workers themselves along with the cooperative of managers and work authorities is important. The studies regarding relation between noise and cardiovascular system are little, more work must be done to understand and acquire this issue.

1.2 Previous Studies

There is growing evidence that noise adversely affects health in general, and the cardiovascular system in particular (WHO, 1999; Rosenlund, 2001; Fong & Johnston, 2000; Truax, 1999; and Talbott EO, Gibson LB, Burks A, Engberg R, McHugh KP, 1999). Although dose-response interaction for these factors are not well understood.

Many studies have been done worldwide to find out the negative effects of noise. A study performed on automobile drivers (Chang TY, Jain RM, Wang CS, Chan CC., 2003) found a significant difference of 16 mmHg in sleep-time systolic blood pressure (SBP) existed between two exposure groups, and a marginal increase of SBP as a result of increase in occupational noise exposure.

A study carried out by the Robert Koch Institute on behalf of the German Federal Environmental Agency (Federal Environmental Agency (UBA), (2003), showed that people who endured a relatively high sound level by their bedroom windows were almost twice as likely to be treated for high blood pressure as those people exposed to a lesser sound pressure. Relative risk increased for persons sleeping near open windows.

(Hanini, 2002) found that there is a strong correlation between sound pressure and arterial blood pressure (systolic & diastolic), pulse rate, and hearing threshold levels at different frequencies.

(Abdel-Raziq H.R. 2000) showed that there is a strong relationship between sound levels and arterial blood pressure, pulse rate, and hearing threshold in school children. Also (Abdel-Ali, 2001) showed that in Nablus city in the west bank, 49% of workers are exposed to noisy factories.

Another study to determine the possible effects of Occupational noise on workers were done in Poland (Powazka, K. Pawlas, B. Zahorska-Markiewicz, et al. (2002), where a randomly-selected group of workers in a metallurgical plant was examined. The "high" exposure workers had significantly increased systolic blood pressure levels, compared with the "low" exposure men - averages of 125 mm Hg vs. 121 mm Hg. Average diastolic pressures were the same in both groups - 80 mm Hg.

A study have been made to determine the Long-term effects of occupational noise exposure on auditory processing in the human brain concludes that exposure to occupational noise causes long-term effects on the cerebral processing of speech sounds, and also increases auditory distractibility (Brighton, 2000).

Another study to find the effects of aircraft noise on people who lived under an airport flight path reported that people exposed to relatively high aircraft noise levels were 60% more likely to report have been diagnosed with high blood pressure. Those with higher exposures were 80% more likely to report a high blood pressure diagnosis. (Rosenlund, M., Berglind, N., Pershagen, G., Järup, L., & Bluhma, G., 2001).

A review and analysis of 43 epidemiologic studies (Van Kempen Elise E. M. M.,1 Kruize Hanneke,1 Boshuizen Hendriek C.,2 Ameling Caroline B.,1 Staatsen Brigit A. M.,1 & de Hollander Augustinus E.M. 1., 2002). Concluded that a significant association between noise exposure and hypertension exists.

Chapter Two

Theoretical Background

2.1 Noise pollution Definition

Why there is so concern about the environment? Why concepts such as: pollution, air pollution, water pollution, soil pollution, food pollution, global warming, ozone, radiation, insecticides, and noise pollution are becoming more and more popular and attracting public opinion. Why this is now a worldwide major social and political issue? The answer is clear and simple; impacts from the deterioration environment on human health are evident and tragic. Diseases and vulnerable health are traits of our modern life (Botkin & Keller 2000). We live in a time where technology gives us a lot, but also adversely affects us.

One major issue due to this technology is noise pollution. The noise pollution before technology is incomparable with pollution of modern society, where many factors contribute and increase the problem widely, increasing population with urbanization and its implications (especially in modernized world), such as increasing numbers of roads, rail and air traffic. We live in a noisy background; the upsetting sound of aircrafts, the disturbing noise from industry, and noise from transportation annoys and exhausts us. Noise Pollution has been recognized as a major threat to human well being. It has been proved that noise in extreme limits, can damage hearing and be classified as a hazard (WHO, 1999).

In a conference held in Rosario, Argentina, on September 29 and 30, 2000, participants agreed on the definition of the expression "Acoustic Violence", to refer to the new approach of considering noise pollution as an instance of violent behavior. They agreed that the Acoustic Violence is a pattern of the present society. This means that noise can be not only annoying but also damaging to the health. Even scientists said that growing levels of human-caused noise in the oceans is disrupting and/or killing whales, dolphins, and other marine life (Sparrow, 2002).

The attempt to give a clear, comprehensive, and reliable definition for noise is not simple. It is mainly subjective to a great extent, what is considered ordinary or enjoyable for someone is considered for others annoying and disturbing sound. This depends on many factors, information content of the sound, time of occurrence, temporal quality, frequency, impulse and tonal content, transmission route, specific source, the condition at the moment, the activity engaged in, and the level of current need for quiet, etc..., . As a result, it is difficult to provide a scale for the degree of annoyance caused by a sound. In general noise is defined as: Harmful or unwanted sounds in the environment, which in specific locals, can be measured and averaged over a period of time (GEMET, 2000).

2.2 Background and basic concepts

Studying noise requires the understanding of many basic and essential concepts and information, which are involved in the study of noise such as the ear physiology, hearing process, sound, and physical quantities for measuring the noise (frequency, sound intensity, sound pressure, sound pressure level, and decibel).

2.2.1 Anatomy of Ear

The natural life requires hearing. The ability to know and discriminate what is moving around is giving us an outstanding survival advantages. Also, human social activities depend largely on talk and speech communications. In our body the ear perhaps is the only part that gets or receives the noise. So understanding its physiology and hearing process is important to understand why noise has large adverse effects. The human ear consists of three main parts: The outer ear, the middle ear, and the inner ear (Arnold, 1995), as shown in (Figure 2.1).

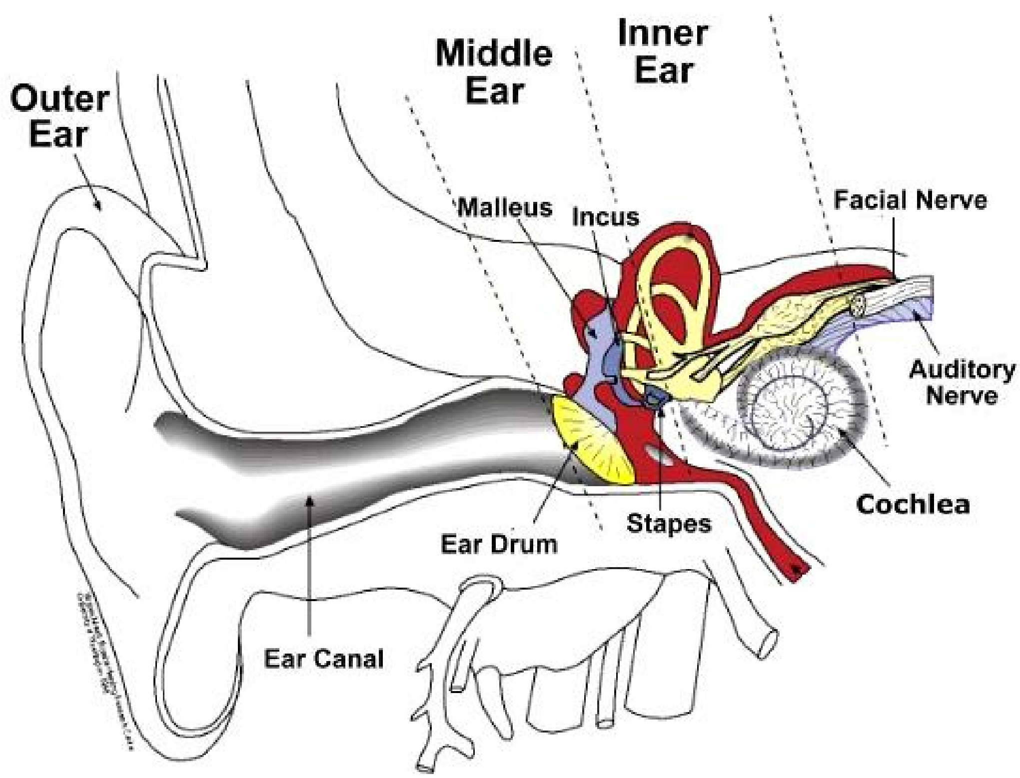

Figure 2. 1 Anatomy of Ear

The outer ear consists from two portions, largely cartilaginous external tissue called the pinna or auricle, and the auditory canal. This tube connects the outer ear to the inside or middle ear. After this comes the eardrum (tympanic membrane). This divides the external ear from the middle ear. Middle ear (tympanic cavity), consisting of: the auditory bones, (the auditory ossicless), which are three tiny bones that are connected and transmit the sound waves to the inner ear. The bones are called (the malleus, the incus, and the stapes) (Howard & Angus 2001). These bones have more common names: the hammer, the anvil, and the stirrup, respectively. The three bones form a system of levers linked together, hammer pushing anvil, anvil-pushing stirrup. The bones double or often treble the force of the vibrations reaching the eardrum (Roberts, 2002). Mitigation of potentially harmful amplification occurs via muscles of the middle ear. These muscles operate as safety apparatus to protect the ear against extreme vibrations from very loud noises (Howard & Angus, 2001).

And the last section is the inner ear which is consists of:

1- Cochlea (contains the nerves for hearing). The cochlea is a spiral tube that is coiled around the cochlear nerve. The cochlea has a main role in hearing process (Howard & Angus, 2001).

2- Vestibule (contains receptors for balance).

3- Semicircular canals (Howard & Angus, 2001).

2.2.2 Hearing Mechanism

Hearing starts with the outer ear. The sound waves, or vibrations, pass through down the auditory canal, and strike the eardrum (tympanic membrane). The eardrum vibrates. Air molecules under pressure cause the tympanic to vibrate. Low frequency sound waves produce slow vibrations and high frequency sounds produce rapid vibrations (Roberts, 2002). The vibrations are then passed to the auditory ossicless. The ossicless amplify the sound and send the vibrations to the oval window (in the inner ear). The vibrations that reach the inner ear through the oval window cause a pressure changes that vibrate the perilymph, these vibrations are transmitted across the vestibular membrane to the endolymph of the cochlear duct. Almost all the sensitive, important and indeterminate job is taking place in the inner ear where a membrane (basilar membrane), presenting in the cochlea. Which in turn vibrates at a particular frequency, depending upon the position along its length where high frequencies vibrate the window end where the basilar membrane is narrow and thick, and low frequencies vibrate the other end where the membrane is wide and thin. The nature of the basilar membrane is important for frequency discrimination. The vibrations move the hairs which in turn excite the associated nerve fibers. The basilar membrane (with tens of thousands of nerve endings embedded in it) vibrations are then bending the tectorial membrane, which contains the hair cells (Pickles, 1988). The location of the hair cells associated with the nerves is highly correlated with the frequency of the sound. The amplitude of a sound determines how many nerves associated with the appropriate location. The main effect is that a loud sound excites nerves along a fairly wide region of the basilar membrane (Roberts, 2002). While a soft sound excites only a few nerves. Vibrations allow the entry of ions into the hair cell and a generator potential is arise. The action potentials are transmitted along the cochlear branch of the nerve, activating auditory pathways in the central nervous system. Once the sound waves reach the inner ear, they are converted into electrical impulses which the auditory nerve sends to the brain. The brain then translates these electrical impulses as sound (Roberts, 2002).

2.2.3 Sound

Sound can be defined as: any vibration in the air or other medium, some types of which are able to cause a sensation of hearing (Truax, 1999). We hear sound because our ears respond to sound waves of high and low pressure traveling through the atmosphere; wave is produced by a force that vibrates the surrounding air molecules, colliding into other air molecules. Where the vibrations composed of alternating compressions and rarefactions reaches the ear.

2.2.3.1 Sound Intensity and Sound Pressure

Sound intensity is defined as the sound power per unit area. The basic units are watts/m^2 or watts/cm^2. Sound intensity measurements are usually made relative to the standard threshold of hearing intensity I_0:

$I_0 = 10^{-12}$ watts/m^2 = 10^{-16} watts/cm^2 (Snyder, 2000).

Sound pressure can be defined as the difference between the instantaneous pressure at a point in a sound field and the average pressure at that point (The American Heritage Dictionary of the English Language, 2003). The pressure is the force per unit area, where force can be measured in Newton or dyne and area can be measured in square centimeter or square meters. It is the sound pressure rather than the intensity of the sound wave which our eardrums react to. The atmosphere exerts pressure on all objects in it (Snyder, 2000). When a vibrating body moves in air, it creates slight disturbances of the atmospheric pressure. The oscillating variations in sound pressure propagate in the form of a sound wave. Sound pressure may be measured in dynes per square centimeter (dynes/cm^2) or Newtons per square meter (N/m^2), or Pascal (Pa). Where 1 Pascal =1 N/m^2 = 10 $dynes/cm^2$ (Snyder, 2000).

2.2.3.2 The decibel

The decibel (dB) is a logarithmic scale used to denote the intensity, or pressure level, of a sound relative to the threshold of human hearing. A normative human ear can detect a pressure as small as 0.00002 Pa or 20 μPa which equal to 0.0002 $dynes/cm^2$, where the frequency of the sound is equal to1000 Hz (Howard and Angus, 2001). This reference pressure has been internationally agreed upon it, and usually called the threshold of hearing (Barlow & Mollon, 1982). The pressure variations within the range of perception by the human ear lies between 20 μPa (audio threshold) and 200 Pa (pain threshold) (Roberts, 2002).

This means that there is a huge range or scale to deal with. To avoid having to deal with such massive numbers.The decibel scale was therefore introduced to reduce this ratio to a more practical size by the use of logarithms. Instead of expressing pressure in units ranging from a million to one, it is found convenient to condense this range to a scale 0 to 140 and give it the units of decibels (dB). 0 dB is close to the lowest human aural threshold for a frequency of 1000 Hz. The decibel scale is therefore not an absolute unit of measurement such as Hz. Rather it only specifies the relationship to the audio threshold, i.e. it tells how much a sound exceeds the audio threshold. The decibel is an unusual or fixed measurement (Snyder 2000).

We can write the equation that gives the decibel:

dB = 20 log (p1/p2).

Where p1 is the measured effective pressure of the sound wave, and p2 is the reference effective pressure, where P2 equals 0.0002 Pa, or the pressure value of 0.0002 dyne/cm^2. So the threshold level takes the value 0 decibels (0 dB). The following are common examples of the decibel scale readings;

- 0dB the weakest sound we can hear.
- 30dB a quiet location in the country.
- 45dB typical office space.
- 60dB restaurant at lunch time.
- 70dB the sound of a car passing on the street.
- 80dB loud music played at home.
- 90dB the sound of a truck passing on the street.
- 100dB the sound of a music band.
- 115dB limit of sound permitted in industry.
- 120-140 dB deafening.

2.2.3.3 A-weighted decibels, dB(A)

As a rule, sounds consist of a mixture of high, medium and low frequency segments. The human ear perceives these frequency segments with various degrees of sensitivity, low frequency sounds of the same dB level are not heard as loud as high frequency sounds (Roberts, 2002). In order to reflect these properties of the ear, measuring devices are equipped with acoustic filters. The acoustic filter "A"; shows the best correspondence between ear and measuring device for the usual environmental sounds.

Practically all noise is measured using the A filter. The corrected sound volume is therefore given in "dB (A)" (Howard & Angus, 2001).

2.2.3.4 Loudness

It's acceptable that sound energy (vibrations) that enters the ear is converted into neurological impulses (Pickles, 1988), with all the neural processing points along the way. The psychological sensation of loudness is related to the intensity of the energy carried by the sound waves. The wavelength of these sound waves is sensed as the pitch of the sound, whereas the amplitude of the waves is perceived as loudness. Pitch is related to frequency, where frequency is a measure of how frequently a vibration repeats itself (oscillates) or the number of waves passing by in a second (Truax, 1999). A hertz is the unit of frequency which is 1 oscillation per second. The sensation of loudness is affected by the frequency of the sound. At the low ends of the frequency range of hearing.

Loudness isn't a physical quantity, but fairly a personal sensation that humans have as part of our hearing. It is related generally to the size or closeness of a sound source, other factors also involved, frequency, spectral content, the presence of other sounds, possibly masking sounds, place, time of exposure, and the recent history of sound perceived. Loudness is a very complex sense (Howard & Angus, 2001). It would be helpful if such sensation correlates with physical quantities such as sound-pressure level (SPL), but it does not.

The acoustical characteristics of speech, sound, music, and noise can be measured with considerable precession using the appropriate instruments. The results also can be expressed in terms of physical parameters (frequency, power, pressure level, etc). By contrast the full and comprehensive interpretation of hearing mechanism is not completely understood. So it cannot be expressed in terms of physical parameters. This leads to statistical manipulation to understand the issue (Roberts, 2002); it becomes an objective and personal opinion.

2.3 Noise Pollution Sources

According to the World Health Organization's Guidelines for Community Noise, aircraft noise is more annoying than road traffic, which in turn is more annoying than noise from railways. Furthermore, transportation noise not only produces temporary annoyance, but also is a cause of lasting health impairments (WHO, 1999).

2.3.1 Transportation

While many sources are confined inside buildings and walls, away from public, noise from transportation propagates into the surroundings, annoying large and various portion of peoples. This source is important because of the large and growing number of it.

2.3.1.1 Road traffic

Traffic noise is an important source or may be considered as the most widespread source, which constitute an important environmental health problem for the people exposed (Purdom, 1980). While noise from many sources is kept inside buildings and walls, noise from transportations is affecting a major portion of peoples. The engines, the friction of the wheels over the road surface, the intensity of traffic and travel speed are considered the major sources of road noise. Noise level is strongly related to speed. For instance a car traveling at 20 km/hr emits 55 db of rolling noise, at 40 km/hr 65 dB, at 80 km/hr 75 dB and at 100 km/hr 80 dB. There is also convincing evidences that along major highway arterials in inter-urban areas, noise emissions alter the living environment of wildlife species (Rodrigue, 2003).

In a study performed in Stockholm to estimate the degree of annoyance, sleep disturbances and hypertension, which can be related to road traffic noise in residential settings. It has been shown that risk differences and 95% confidence intervals were calculated for annoyance and sleep disturbances (Liberman, 1990). Another study was performed in Sydney (ABS, 1997), showed that 1.5 million residents were exposed to outdoor traffic noise levels which considered as undesirable (between 55 and 65 dB (A)), where sleep and amenity are affected. 350,000 of these residents were estimated to experience noise levels considered as unacceptable (greater than 65dB (A)), where behavior patterns are constrained and health effects are demonstrable.

In Europe, the population exposed to levels above 65 dB(A) increased from 15% in 1980s to 26% in the early 1990s (WHO, 2000). Available evidence underlines that around 45% of the population in developed countries live in high levels of noise intensity (over 55 dB) generated by road transportation. Although some site specific measurements have been taken in response to particular issues, there is a general lack of consistent data on the impact of road traffic on noise levels within the state and even within urban areas. The lack of background noise data collected both before and after construction of new roads or expansion of existing ones, has made it difficult to assess the impact on ambient noise levels.

In Palestine there is a growing concern in studying the noise pollution in general. A study was performed in Gaza Strip (Sarraj, 2001), showed that there was a big increase of registered vehicles, which caused a lot of traffic problems including noise pollution.

2.3.1.2 Air traffic

Air transportation noise constitutes a considerable portion of total noise emissions by transportation. Air transportation took a growing weight in inter-city transportation, were the jet engines is used, as a result noise emissions have increased considerably. The most effected areas are localized nearby airports (Rodrigue, 2003). Noise essentially comes from several sources; the jet engine, the aerodynamic friction, and ground craft operations. Noise from aircraft operation is having direct impact on residential areas around airports. This effect is distributed along major approach and takeoff lanes. The issue of previously unaffected by aircraft noise but recently is affected has call for national attention over recent years (Fidell, 1990; Weiner, 1990; Mouat, 1990).

The impact of noise is greatest close to the airport itself and under the flight paths. Daytime aircraft movements at Heathrow, Gatwick, Stansted, and Manchester airports (carrying 126 million passengers) caused moderate disturbance to 69,500 people over 83.7km2 in 2002 (Ormerod, 2004).

National and international regulations specify maximum noise limits for all civil aircraft. The limits vary according to the size and type of aircraft. Measures introduced to reduce noise include Noise Preferential Routes, restrictions on night flying and noise insulation award projects. The improvement is a multipart combination of operational controls, maximum noise limits monitoring, planning conditions and direct measures imposed by the in charge authorities (Ormerod, 2004).

2.3.1.3 Rail traffic

Rail Transportation Noise constitutes 10% of total noise emissions by transportation (Geography, 2003). There are two main sources of noise relating to rail traffic, first is the operation of the rail network with all its implications, the operation of trains, which includes the type of engine (mostly diesel), the speed of the train, friction of wheels over the rails, track type, conditions, and whistle blowing. Second are the maintenance and construction processes of rail infrastructure. Sometimes high speed trains produce areoacoustic noise which considered more important than other sources. Depending of the train aerodynamics, noise emissions are closely related to the logarithm of train speed and become significant at speeds higher than 200 km/hr.

The level of exposure is obviously related to the importance and location of rail transportation infrastructure. The most important noise impacts of rail operations are in urban areas where the majority transshipment functions are performed. Furthermore, rail terminals are often located in the central and high density areas of cities. Rail noise can be considerable, but generally affects a far smaller group of the population than road or aircraft noise as it is generally confined to residents living along rail lines in urban areas (ABS, 1997).

It is important to mention that transportation noise have its own price, this includes costs associated with building noise barriers alongside major transport routes, insulating affected buildings and the lowering of property prices for residential and commercial buildings. Noise costs are difficult to quantify and so estimates can vary widely (ABS, 1997).

2.3.2 Construction noise

The noise from construction is a major source for noise. Construction noise sources include highways construction, air compressors, loaders, cement mixers, welding, hammering dump trucks, and pavement breakers. Construction equipments are often noise producing due to its nature or because of neglecting maintenance. Building operations are often carried out with considerable noise (WHO, 1999; Suter, 1991).

2.3.3 Noise in Buildings

This problem is arising from the buildings structure, it is very clear between apartment dwellers especially when the building is not well planned and constructed. This leads to get out the noise from one apartment to another or outside the buildings (WHO, 1999). Sources for internal building noise are various, such as, air conditioners, plumbing, boilers, generators, heat pumps, plumbing systems, and fans. Sometimes external noise from outside can enter inside, making the situation even worst. Some examples are emergency vehicles, traffic, and refuse collection. This is a very common problem for urban residents, especially when there are improperly insulated walls and ceilings. The knowledge to solve these problems is not being applied. In Administrative Conference of the United States there was an opinion said that the quality of construction is declining, and the noise problems are getting worse (Wetherill, 1991).

2.3.4 Domestic noise

Many variable sources of noise can be classified in this category, (noise from neighbors) such that barking dogs, car alarms, motorcycles, garbage recycling, vacuum cleaners, washing machines, TV sets, music reproduction, lawn-mowers, and household noise (WHO, 1999). An example is the gasoline-pothered leaf blower, with average A-weighted sound levels at the operator's position of 103.6 dB, and maximum levels of 110-l12 dB (Clark, 1991). A considerable percentage of complaints received by the police and other health supervisors are related to neighborhoods noise (EPA, 1993). This type of noise leads to social problems. The national noise survey in U.S found that noise from barking dogs and road traffic have the greatest impact on residential communities.

2.3.5 Occupational noise (Noise in industry)

Industrial noise is considered as one of the less prevailing noise sources. But these plants have a plenty of machines and devices such as: motors, fans, cutting machines, compressors, and transportation resources. These resources could be, or mostly transferred from the interior to the outside through open windows and doors, and sometimes through building walls. And thus disturb the neighbors of these noisy plants.

These noise sources have considerable impacts on industrial workers. The industrial noise problem is very obvious. Many Institutes and in control involved persons pay attention to this issue. The Occupational Safety and Health Administration (OSHA) in the U.S. play an essential role. It puts the occupational noise standards which guarantee the workers health, such as the OSHA permissible noise exposure (Table 1.1) (OSHA, 2004).

Table 2.1 OSHA permissible noise exposures

Time permitted per day (hour)	Sound Level dB(A)
16	85
12	87
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25 or less	115

Noise considered a common occupational hazard in many workplaces. This is true because most of the machines and devices nature is to emit large noise. In the woodworking industry the sound levels of saws can be as high as 106 dB (Goeltzer, Hansen and Sehrndt, 2001).

Occupational sources of noise constitute a considerable source of noise, this can be harmful for the workers, and every year about 30 million people in the U.S. are occupationally exposed to hazardous noise (OSHA, 2004). The sources of noise in work are several and varied but mainly have a relation to industrial machinery and processes. Such as gears, turbulent fluid flow, impact processes, electrical machines, internal combustion engines, pneumatic equipment, drilling, crushing, blasting, pumps and compressors. Exposure for more than 8 hours a day to sound over 85 dB is risky (NIOSH, 1996). The attempt to lower this type of noise is based on using quieter machines and equipments, or to take away the noisy plants from residential areas. For the workers the best thing to do is to use shields and protection equipments, besides decreasing the working time.

2.4 Noise Pollution Effects

Environmental noise affects health, physically, mentally and socially. There is sufficient evidence showing that high noise levels interfere with speech and communication, cause hearing difficulties, hearing impairment, sleep disturbance, increase stress-related hormones, blood pressure changes, heart disease. Noise can adversely affect performance, for example in reading, attention, problem solving and memory. Deficits in performance can lead to accidents, headaches, frustration, tolerance, and student learning. Also reduction of digestive secretions, the resulting effects of the sympathetic response is increased heart rate, metabolism, and overall oxygen consumption (Goeltzer, et al. 2001).

2.4.1 Physiological Effects

The physiological effects include auditory effects; hearing loss, hearing impairments, and non auditory effects (WHO, 1999).

2.4.1.1 Auditory effects

The hearing common sense is important to a great extent, even it is considered essential (more than any other sense) for mental and social development of humans (Griefahn, 2000). The relationship between noise and hearing loss considered certain in the scientific community (Fong & Johnston 2000). Noise causes hearing loss or hearing difficulties of hearing ability, this is may be most common or obvious effect of noise. A very high amplitude impulse can cause rupture of the ear drum, or disturbances to the middle ear bones, this is called traumatic hearing loss, (Demetroulakos & Salem, 2003). Some hearing problems are in part reversible while others are permanent. Long exposure to high industrial noise level can cause hearing impairments (Goeltzer, et al., 2001). Because permanent hearing loss is usually a long-term process, it is impossible to know at exactly what point noise becomes loud enough to cause damage to the ears.

2.4.1.2 Non-auditory physiological effects

Noise causes stress (hazardous to the health), and stress is a principal cause of bad health. Therefore noise can be considered pollution if it causes any stress reaction, such as annoyance, sleeplessness, fright, or other symptoms. Exposure to excessive noise can also induce or aggravate stress-related health outcomes, including immune system, sleep, task performance, behavior, and mental health (Fong et al., 2000).

A link between noise and mental health problems is suggested by the demand for tranquillizers and sleeping pills, the incidence of psychiatric symptoms and the number of admissions to mental hospitals, Stimulating the sympathetic nervous system response. Psychological reactions to noise may include irritability, anxiety, impaired judgment, altered perceptions, and difficulty concentrating. Noise may influence the level of reaction further. Noise above 80 dB may increase aggressive behavior; noise at high levels can negatively impact one's mental performance. A study shows that in a noisy environment there is a direct relationship between the noise levels and the negative psychological effects on workers, (Goeltzer, et al., 2001).

2.4.1.3 Noise and vascular effects

The damaging effect of noise on hearing ability has been confirmed in many studies. However, a few researches have been made to determine the possible effect of noise on other body systems such as the cardiovascular system. Its role as a risk factor for high blood pressure (hypertension) has been proposed, but good evidence has so far been lacking (Powazka, Pawlas, Zahorska-Markiewicz, *et al*., 2002).

2.4.2 Social Impacts of hearing loss

In addition to the widely unexpected negative effects there are others, social and economic price must be paid. Noise interferes with normal speech causing wrong and confuse responses. This will cause social price. Those who have problems in hearing will face challenges, (Snyder, 2000). They must adjust themselves to live with the adaptive devices that make it feasible for them to live independently. They have to adjust to use hearing aids and may be learning sign language, as a result of isolation (from the failure to communicate with people around them and difficulty in accepting their disability).

2.4.3 Action of noise

The most accepted opinion says that noise can damage or heart the sensory cells in the inner ear. This can be occurs as a result of:

1- Damage of cochlear tissue as a result of the force of the sound pressure.

2- Cardiovascular factors resulting from diminished blood supply to the cochlea during noise exposure.

3- Alteration of fluid transport across Reissner's membrane during noise exposure.

4- Alteration of biochemical processes during noise exposure, (Stansfeld, 1992).

The hair cells normally convert the mechanical energy of sound vibrations into neuro-electrical signals that are transmitted to the brain. As the intensity of the noise or the time for which the ear is exposed is increased, a greater proportion of the hair cells are damaged or destroyed.

Chapter Three

Methodology

3.1 Study Sample

The sample of this study consists of 96 workers, all are males, the study did not examine any female. There are many reasons for choosing the males only. First is the ratio of females to males is low (this was concluded from the survey which was performed prior to the beginning of the study). Second is that the managers were uncomfortable to carry out the tests on the female workers, due to customs and traditions. The third reason is the fact that most of female workers work in almost a single field of work, which is the textile and sewing production. The workers ages were between 20 to 45 years (with mean value of 30.5 year). The workers belong to twelve different industrial plants. The duration of the data collection (readings and measurements) lasts for three months (June, July, and August, 2004).

The statistics were performed for workers satisfying the following conditions:

1) Aged 20-45
2) Similar work hours.
3) Healthy, no history of cardiovascular diseases or hearing difficulties.
4) Body mass.
5) Years of present work or working at the same work at least two years.

6) Ready to accept the tests voluntary, no obligation was required.

Workers and their supervisors understood clearly the objective of the study. Most of them were collaborating (cooperative) and simplify the effort done to do the study. Each measurement was repeated twice then the mean was calculated. For each worker the blood pressure (systolic and diastolic), pulse rate, and threshold levels of hearing were measured.

The arterial blood pressure is very sensitive, and can be changed for many reasons such as eat a salty meal, smoking, nervous, hereditary, and disease. The workers were asked not to eat salty food or smoke heavily before at least one hour the measures were taken place. Also the settings when taking the measurement were quiet and attention has been taken not to make the worker feel nervous or worried.

3.2 Instrumentations

Three devices were used in this study to measure sound level meter, blood pressure (systolic and diastolic), and hearing threshold level. Brief information is given about each in the following three-subsections.

Each instrument was checked and calibration was performed when needed

3.2.1 Sound Level Meter

The Sound Level Meter is the fundamental instrument used to measure the noise. It is designed to approximate the loudness level sensitivity of the human ear. It gives objective, reproducible measurements for the sound pressure level. This involves a complex work to acquire the frequency range, spectral weighting of the sound, along with the application of time constants, and calculation of the equivalent continuous level. The microphone converts the sound to an equivalent electrical signal, which varies in with the acoustical signal. The output signal from the microphone is very small and needs to be converted in the preamplifier before further processing takes place (Manual Instructions for Sound Level Meter).

The Sound level meter calculates the A- and C-weighted Peak and RMS values simultaneously. It contains one C-weighting and one A-weighting network as well as one Peak and one RMS detector. After detection of the RMS and Peak values, the signals are digitised in the analogue-to-digital converter. The level signals are represented by digital signals. They are processed by the microcomputer which also controls the display, converts the values to decibels and calculates the Leq and the C-A value. The time constant is also involved on the signals by the microcomputer. The sound level meter should be placed to avoid nearby reflecting surfaces and be far enough from the source.

The sound level meter essential components block diagram are indicated in figure (3.1).

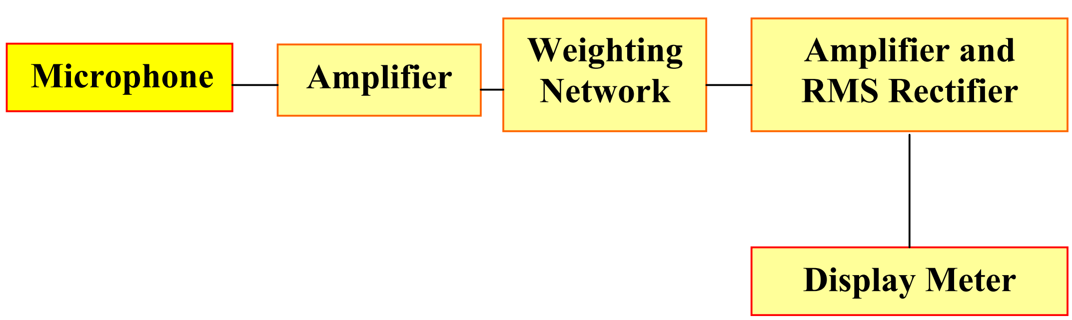

Figure 3.1 Block diagram of sound level meter

In this study sound pressure level meter measurements were carried out 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 25ºC. This device gives the readings with precision of 0.1 dB (A).

3.2.2 The Audiometer

The threshold measurement of hearing was performed for different frequencies (0.5, 1, 2, 4, 6, 8 KHz).

Manual Audiometer (MicroLab Audiometer, (ML-AM)) with accuracy ±3% at operating temperature 10 ºC to 45ºC was used.

3.2.3 Wrist Blood Pressure Monitor

The blood pressure (systolic and diastolic) and pulse rate were measured for each worker by Automatic Digital Electronic Wrist Blood Pressure Monitor (Medical Rossmax, model Z46) with accuracy of ±3 millimeter Hg, and ± 3% of reading pulse rate with operating temperature range of +10ºC to 40ºC.

3.3 Stages of the study

The first stage in implementing the study is to classify the various plants into different categories. This was done by gathering information about the industry situation in Jenin from the municipality, Ministry of Labor, and the Palestinian central statistical bureau.

The following stage after classifying the factories into different categories is to select a representative sample for each category. The sample should satisfy the conditions: more than ten workers, the worker should have two years at least in working the same work, the workers work at least for 8 hours, and the existence of quiet place to perform the tests.

The next step was to visit the selected factories to inform them about the study and take the permission for doing the measurements. After taking the agreement, regular visits were taking place to measure the sound, using sound level meter. The sound level meter was placed in the centre of the plant, where the workers spent most of their time. Also this measure was repeated many times with different locations (for each plant) to assure that the obtained value is a good representative for the plant noise. Then the measurements for the workers were taken twice a day. First in the morning before the workers begin working, and the second after 4-5 hours after the beginning of work. The measurements include systolic and diastolic blood pressure, pulse rate by using portable wrist blood pressure monitor, and hearing threshold level by using the Audiometer.

3.4 Statistical Analysis

The obtained data were ordered and analyzed statistically using the SPSS program. The average values were expressed as group means ± SE. Matched T- test was used to identify the associations between dB(A) and pulse rate, arterial blood pressure and hearing threshold. The test was performed to explore the differences for the measured quantities before and after the exposure.

Chapter Four

Results

4.1 Noise pollution results

In this study it has been tried to investigate part of the effects of occupational noise pollution on the workers in Jenin region. Many variables such as sound pressure levels, arterial blood pressure (systolic, diastolic), pulse rate, and hearing threshold levels were measured and analyzed. An attempt to find any relation between these variables was performed. Table 4.1 shows the different noise levels found in Jenin plants.

Table 4.1 Noise pollution levels in dB(A) at the studied plants.

	Plant Name	Plant Type	Number of examined workers	L_{eq} in(dBA) (Mean Value)
1	Al-Ashqar oven factory	Metal	5	78.2
2	Al-Marah company	Metal	13	82.5
3	Mohamad smithery factory	Wood	4	84.8
4	Abu-Alseba fodder company	Food	4	85.3
5	Suboh concrete company	Concrete production	6	86.2
6	Al-Jalboni concrete factory	Concrete production	12	87.4
7	Al-Ghol flagstone factory	Concrete production	7	87.6
8	Hadad factory	Metal	16	89.6
9	Al-Naqash stones	Stonecutter	5	91.6
10	Zidane Bricks factory	Concrete production	4	91.4
11	Al-eitemad smithery factory	Metal	4	92.4
12	Al- shohda bricks factory	Concrete production	3	93.4
13	Al-Hindi bricks factory	Concrete production	4	98.2
14	Al-aqsa stonecutter	Stonecutter	4	98.4
15	Al-Anbar stonecutter	Stonecutter	5	98.5

From table 4.1 the sound pressure level for the plants lies between 78.2 to 98.5 dB(A), with mean value of 89.7 dB(A), which can be considered a high value (according to OSHA permissible noise exposures above 90 dB(A) with eight hours working is considered risky, recall Table 2.1). One plant (6.66%) have value of dB(A) under the value of 80 dB(A). with five workers (5%). Seven of fifteen plants (46.7%) have values between 80-90 dB(A), with 62 workers (65%). The other seven plants (46.7%) have values of dB(A) higher than 90 dB(A), with 29 workers (30%). The working hours of these plants are similar (almost 8 hours), so the working hours will not be considered as a factor.

4.2 Arterial blood pressure (systolic and diastolic), pulse rate, and hearing threshold levels for plant workers results

Arterial blood pressure (systolic and diastolic), pulse rate, and hearing threshold levels of right and left ears values (mean ± standard deviation) for all the workers are given in tables 4.2, 4.4, 4.4, 4.5, 4.6.

The given values are obtained from making the calculations using the Excel Program.

Table 4.2 Mean values (± standard deviation) of blood pressure (systolic & diastolic), and pulse rate before exposure

dB(A) level	**Systolic (mmHg)**	**Diastolic (mmHg)**	**Pulse rate (Beats/minute)**
70-80	115± 9.1	66.4± 5.8	76.6±8.2
80-90	120.5± 9.4	72± 6	77.7±8.3
90-100	118.3± 8.3	69±5.2	75.1±9.8

Table 4.3 Mean values (± standard deviation) of blood pressure (systolic & diastolic), and pulse rate after exposure

dB(A) level	Systolic (mmHg)	Diastolic (mmHg)	Pulse rate (Beats/minute)
70-80	118.8±8.7	70.6±6.9	82.6±7.6
80-90	122.7±8.1	73.6±5.7	84.9±7.4
90-100	125.7±7.6	78.4±6.3	89.4±7.2

Table 4.4 Net change of blood pressure (systolic & diastolic), and pulse rate before and after exposure

	Systolic (mmHg)	Diastolic (mmHg)	Pulse rate (beats/minute)
Before exposure	117.9	69.1	76.5
After exposure	122.4	74.2	85.6
Net change	4.5	5.1	9.1

Table 4.5 Mean values (± standard deviation) of hearing threshold levels for right ear (before & after exposure)

	Hearing Threshold Levels \ dB(A) level	70-80	80-90	90-100
Before Exposure	**0.5 KHz**	28.6±9	34.1±9.3	36.4±9.2
	1 KHz	21.7±5.6	35.7±7.8	38.3±5.7
	2 KHz	12±3.5	20.8±8.6	26.4±6.8
	4 KHz	12.9±5	17.2±9.2	22.4±8.5
	6 KHz	11.9±5.6	14±6.7	26.2±5.5
	8 KHz	10.6±3.9	13±5.3	25±4.9
After Exposure	**0.5 KHz**	32.7±6.3	35.6±6.2	39.3±8.5
	1 KHz	28.3±5.3	32.8±5.9	41.6±7.5
	2 KHz	16.8±4.4	25.1±5.2	31.2±8
	4 KHz	17.5±7.2	21.7±9.7	22.8±3.5
	6 KHz	18.7±5.6	19.2±7.5	28.7±8.1
	8 KHz	15.9±7.6	17.5±6.6	27.1±5.7

Table 4.6 Mean values (± standard deviation) of hearing threshold levels for left ear (before & after exposure)

	Hearing Threshold Levels \ dB(A) level	70-80	80-90	90-100
Before Exposure	**0.5 KHz**	30.2±7.9	35.5±6.8	37.8±6
	1 KHz	22.7±7.6	34.3±7.4	41.4±8.6
	2 KHz	19.5±7.1	20.1±4.3	30±7.9
	4 KHz	13.6±9.2	16.8±5.8	21.4±5.4
	6 KHz	14.6±4.9	19.5±7.3	23.7±6.3
	8 KHz	12.7±7.3	18±4.2	25±3.9
After Exposure	**0.5 KHz**	37.2±6.8	39±6.3	43.5±6.9
	1 KHz	33.3±5.7	37.8±6.1	46.6±5.8
	2 KHz	22.2±5	30±7.3	36.4±5.7
	4 KHz	22.5±6.3	26.7±7.6	27.1±6.2
	6 KHz	23.7±5.4	23.6±4.4	33.7±8.1
	8 KHz	18.8±3.5	20.8±3.8	30±5.7

Table 4.7 Mean values (± standard deviation) of hearing threshold levels for right and left ears before exposure

dB(A) level	0.5KHz	1KHz	2KHz	4KHz	6KHz	8KHz
70-80	35.5±10	24.3±7.6	22.1±4.5	21.8±7	19.8±6.5	18±4.9
80-90	34.1±10.5	35.7±8.9	20.9±10.2	17.2±11.6	14±7.7	13±7.3
90-100	34.8±13.1	30±5.8	21.5±8	19.5±11.8	16.7±15.5	15.5±6.5

Table 4.8 Mean values of hearing threshold levels for right and left ears after exposure

dB(A) level	0.5KHz	1KHz	2KHz	4KHz	6KHz	8KHz
70-80	35±7.4	30.8±5.8	19.5±4.8	20±8.1	21.3±6.8	18±5.2
80-90	37.4±8.2	35.4±6.9	27.6±8.2	24.3±9.3	21.4±7.5	19.1±6.6
90-100	37.1±10.5	39.9±4.8	28.2±8.1	21.8±8.3	25±11.1	13±5.6

Table 4.9 Net change of hearing threshold levels for right and left ears before and after exposure

	0.5K	1K	2K	4K	6K	8K
Mean before exposure	34.8	30	21.5	19.5	16.8	15.5
Mean after exposure	36.5	35.4	25.1	22	22.6	16.7
Net difference	1.7	5.4	3.6	2.5	5.8	1.2

Table 4.10 Mean values (± standard deviation) of blood pressure (systolic& diastolic), pulse rate, and hearing threshold levels for ears

dB(A) level	70-80		80-90		90-100	
	Before exposure	After exposure	Before exposure	After exposure	Before exposure	After exposure
Systolic (mmHg)	115± 9.1	118.8± 8.7	120.5± 9.4	122.7± 8.1	118± 8.3	125.7± 7.6
Diastolic (mmHg)	66.4± 5.8	70.6± 6.9	72± 6	73.6± 5.7	69± 5.2	78.4± 6.3
Pulse Rate (Beats/minute)	76.6± 8.2	82.6± 7.6	77.7± 8.3	84.9± 7.4	75.1± 9.8	89.4± 7.2
0.5 KHz	35.5± 10	35± 7.4	34.1± 10.5	37.4± 8.2	34.8± 13.1	37.1± 10.5
1 KHz	24.3± 7.6	30.8± 5.8	35.7± 8.9	35.4± 6.9	30± 5.8	39.9± 4.8
2 KHz	22.1± 4.5	19.5± 4.8	20.9± 10.2	27.6± 8.2	21.5± 8	28.2± 8.1
4 KHz	21.8± 7	20± 8.1	17.2± 11.6	24.3± 9.3	19.5± 11.8	21.8± 8.3
6 KHz	19.8± 6.5	21.3± 6.8	14± 7.7	21.4± 7.5	16.7± 15.5	25± 11.1
8 KHz	18± 4.9	18± 5.2	13± 7.3	19.1± 6.6	15.5± 6.5	13± 5.6

4.3 Relationship between sound levels and arterial blood pressure (systolic and diastolic), pulse rate, and hearing threshold levels in studied plants

Analysis of the data using the program (SPSS) software, shows that a strong positive correlations (Pearson Correlation Coefficient) were found between sound pressure levels in dB(A) (noise pollution) and dependent variables (diastolic pressure, pulse rate, and hearing threshold levels) at the following frequencies 0.5K, 1K, 2K, 4K, 6K, and 8K. As shown in (Table 4.11), where the values in table 4.11 were obtained using the SPSS program.

4.3.1 Statistical Definitions

To understand the results of this study there is a few concepts and definitions must be clarified.

4.3.1.1 Pearson Correlation Coefficient

A measure of linear association between two variables. Values of the correlation coefficient range from -1 to 1.

4.3.1.2 Paired-Samples T Test

A statistical test of the null hypothesis that two population means are equal. It is used when the observations for the two groups can be paired in some way, (before and after a treatment.).

4.3.1.3 Significance Level / P-value

The basis for deciding whether or not to reject the null hypothesis. It is the probability that a statistical result as extreme as the one observed would occur if the null hypothesis were true. If the observed significance level is small enough, usually less than 0.05 or 0.01, the null hypothesis is rejected.

Table 4.11 Pearson correlation coefficients between sound level in dB(A) and arterial blood pressure (Sys. and Dais.), pulse rate, and hearing threshold levels at different frequencies in industrial plants

Independent	Dependent	Pearson Correlation coefficient
dB(A)	Systolic	0.22
dB(A)	Diastolic	0.338**
dB(A)	Pulse Rate	0.430*
dB(A)	0.5 KHz R	0.259**
dB(A)	1 KHz R	0.595**
dB(A)	2 KHz R	0.511**
dB(A)	4 KHz R	0.273**
dB(A)	6 KHz R	0.317**
dB(A)	8 KHz R	0.543**
dB(A)	0.5 KHz L	0.279*
dB(A)	1 KHz L	0.564**
dB(A)	2 KHz L	0.210*
dB(A)	4 KHz L	0.280*
dB(A)	6 KHz L	0.318*
dB(A)	8 KHz L	0.237*

Sys. Systolic blood pressure (mmHg); Dias: Diastolic blood pressure (mmHg); P.R: pulse rate (beats/minute); R: Right ear; and L: Left ear.
**: Correlation is significant at the 0.01 level (2-tailed).
*: Correlation is significant at the 0.05 level (2-tailed).

Analysis of the data using the program (SPSS) software, shows that a significant effect for noise pollution on dependent variables (systolic pressure, diastolic pressure, pulse rate, and hearing threshold levels) at the following frequencies 0.5 KHz, 1 KHz, 2 KHz, 4 KHz, 6 KHz, and 8 KHz, This effect was detected by Paired- Samples T test (Table 4.12).

Table 4.12 Paired- Samples T test for dependent variables (systolic pressure, diastolic pressure, pulse rate, and hearing threshold levels) at the following frequencies 0.5 KHz, 1 KHz, 2 KHz, 4 KHz, 6 KHz, and 8 KHz

	Variables	Correlation	Significant P- value
Pair 1	Systolic (before & after)	0.267	0.034
Pair 2	Diastolic (before & after)	0.3	0.017
Pair 3	Pulse Rate (before & after)	0.518	0
Pair 4	RT0.5 KHz A & RT.5 KHz B	0.455	0
Pair 5	RT1 KHz A & RT1 KHz B	0.487	0
Pair 6	RT2 KHz A & RT2 KHz B	0.512	0
Pair 7	RT4 KHz A & RT4 KHz B	0.418	0
Pair 8	RT6 KHz A & RT6 KHz B	0.549	0
Pair 9	RT8 KHz A & RT8 KHz B	0.447	0
Pair 10	LT.5 KHz A & LT.5 KHz B	0.403	0.001
Pair 11	LT1 KHz A & LT1 KHz B	0.701	0.008
Pair 12	LT2 KHz A & LT2 KHz B	0.545	0
Pair 13	LT4 KHz A & LT4 KHz B	0.282	0.025
Pair 14	LT6 KHz A & LT6 KHz B	0.377	0.018
Pair 15	LT8 KHz A & LT8 KHz B	0.599	0

RT: Right Ear**, LT:** Left Ear, **A:** before exposure, and **B:** after exposure

The effect of noise pollution on dependent variables (systolic pressure, diastolic pressure, pulse rate, and hearing threshold levels) is showing apparent and evident role of occupational noise pollution on blood pressure and hearing threshold levels in the industrial plants in Jenin region.

Comparing the averages of the dependent variables (systolic pressure, diastolic pressure, pulse rate, and hearing threshold levels, at the following frequencies 0.5 KHz, 1 KHz, 2 KHz, 4 KHz, 6 KHz, and 8 KHz), Table 4.2 to Table 4.6 showed significantly that there is an increase in the values for the dependent variables as a result of increasing noise pollution levels. From Tables 4.4 and Table 4.8 we can see that the systolic blood pressure is increased by 4.5 mmHg, while the diastolic blood pressure is increased by 5.1 mmHg, the pulse rate is increased by 9.1 beats/minute. The hearing threshold levels also show an increase of 1.2 to 5.8 decibels.

There is a strong correlation between increasing noise and dependant measured values, (Fig. 4.1 to 4.12). The hearing threshold levels of different frequencies are correlating positively with the noise pollution level. From Table 4.4, and Table 4.5, it can be shown that there is a shift of the ear responses as a result of increasing the noise level. It seems that the ears sensitivity is decreased as a result of exposure towards high levels of noise pollution, the difference between ears responses before and after exposure is clear from the given tables and figures, Fig 4.10 to 4.11.

From table 4.2 it is noticed that there is an increase with the measured values of systolic blood pressure, diastolic blood pressure, and pulse rate (before exposure) from 70-80 dB(A) to 80-90 dB(A), then it decreased from 80-90 dB(A) to 90-100 dB(A). This shift was tested statistically, by using the SPSS program; it does not have any statistical meaning. It can be explained on the basis that the sample (90-100 dB(A)) was closer to the smaller ages more than other categories (70-80 dB(A)), and have lesser years of working, As a result there is a shift.

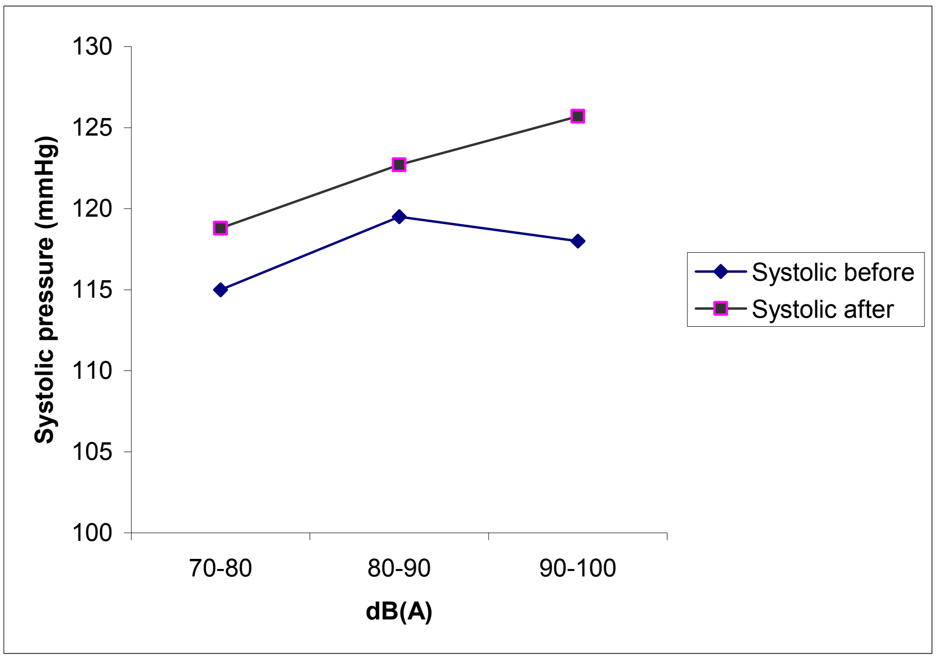

Figure 4.1 Values of average of systolic blood pressure according to noise pollution level (before & after) exposure.

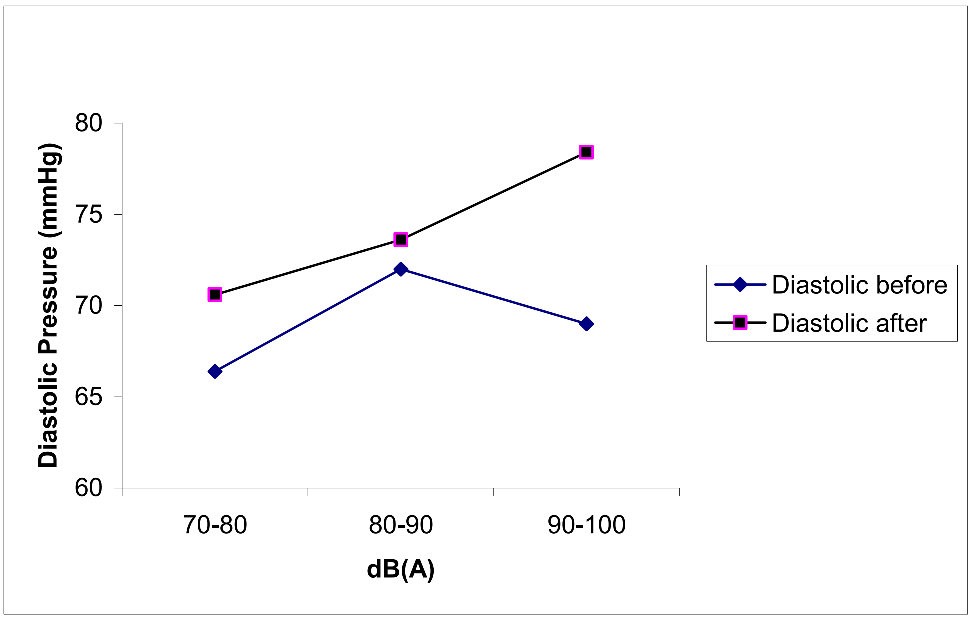

Figure 4.2 Values of average of diastolic blood pressure according to noise pollution level (before & after) exposure.

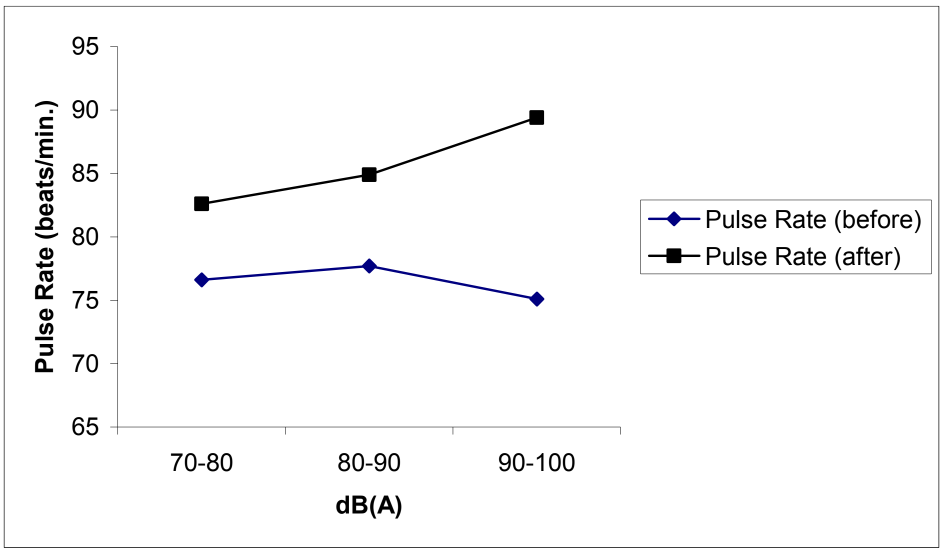

Figure 4.3 Values of average mean pulse rate (beats/min.) relative to different values of sound pressure levels dB(A), (before & after) exposure.

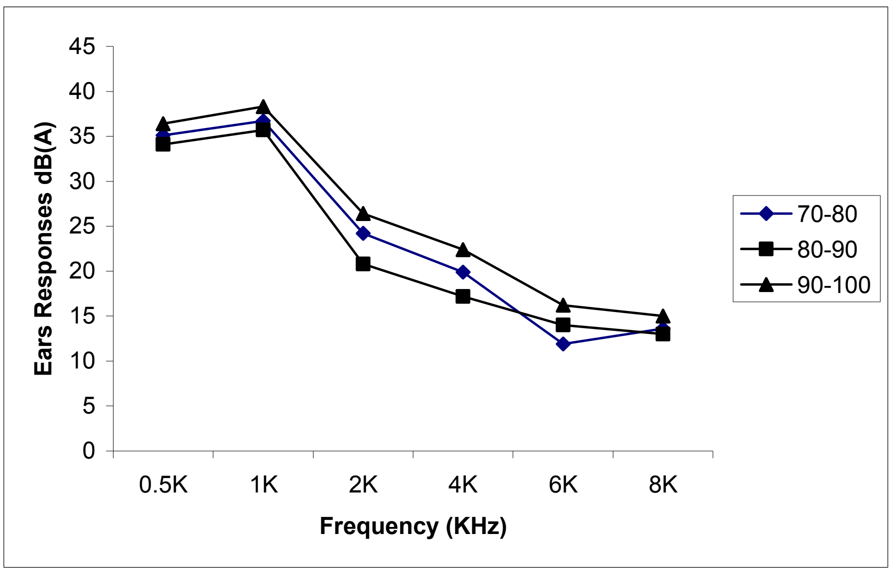

Figure 4.4 Values of average of right ear responses for different frequencies (before exposure) according to noise pollution level.

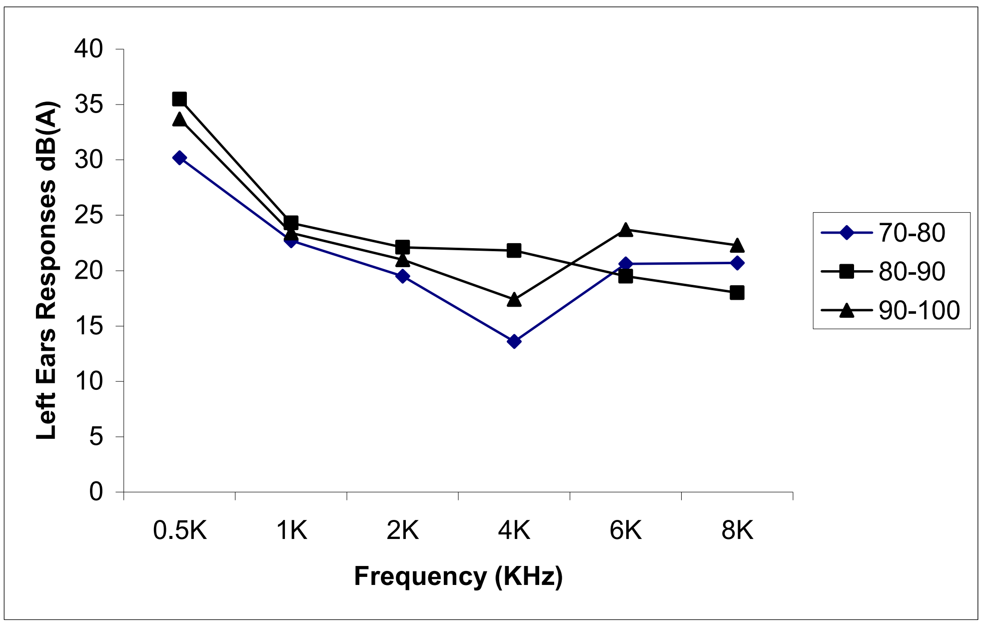

Figure 4.5 Values of average of left ear responses for different frequencies (before exposure) according to noise pollution level.

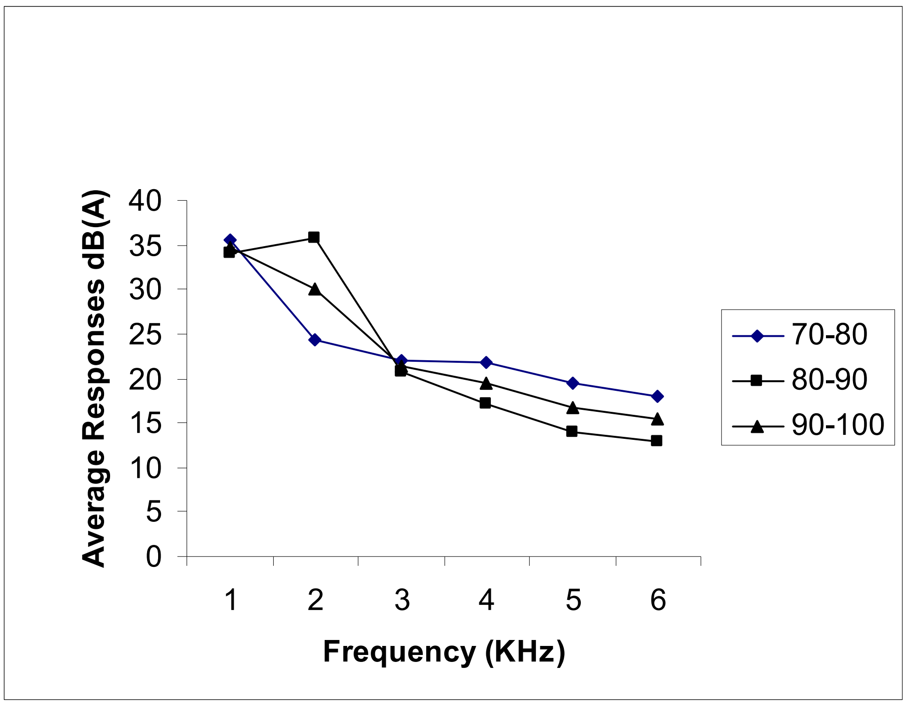

Figure 4.6 Values of average of ears responses for different frequencies (before exposure) according to noise pollution level.

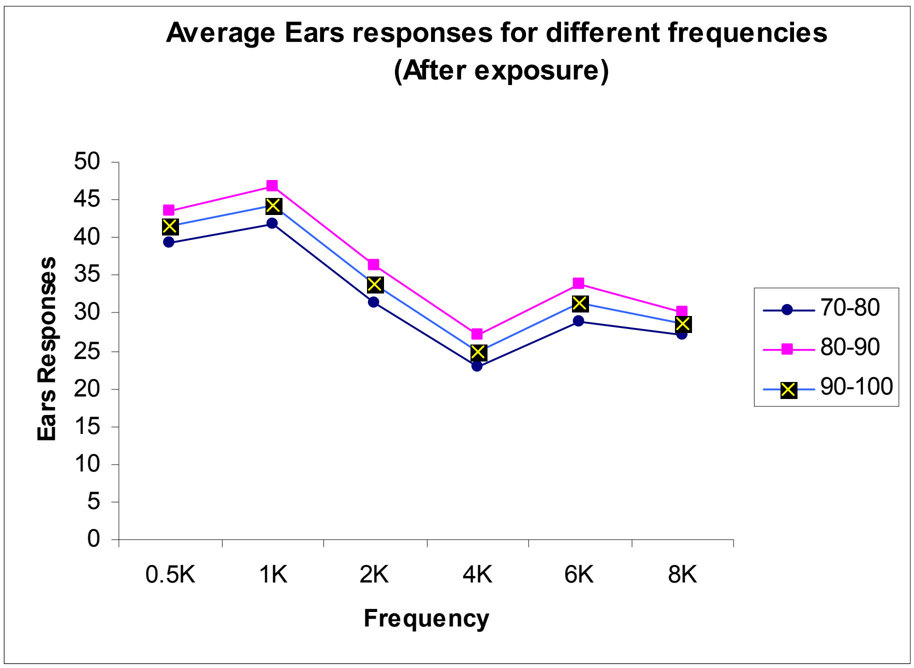

Figure 4.7 Values of average of ears responses for different frequencies (after exposure) according to noise pollution level.

Chapter Five

Discussion

In this study an attempt was implemented to investigate the possible effects of occupational noise exposure on blood pressure (systolic and diastolic), pulse rate, and hearing threshold levels of workers in selected industrial plants in Jenin region in Palestine. The sound pressure level for the studied plants is ranged from 78.2 to 98.5 dB(A), with mean value of 89.7 dB(A), which can be considered a high value. Plants have value of dB(A) under the value of 80 dB(A) constitutes (6.66%), while plants have values between 80-90 dB(A) constitutes (46.7%), the remaining plants (46.7%) have values of dB(A) higher than 90 dB(A). The average working hours in all study plants are eight hours, which accepted by many standard regulations (OSHA, 2004).

From the beginning of this study a hypothesis was set that there is an effect of noise pollution on blood pressure (systolic and diastolic), pulse rate, and hearing threshold levels of workers in selected industrial plants in Jenin region, which was suggested by (Powazka, *et al*., 2002; Abdel-Raziq, 2000; Federal Environmental Agency (UBA), (2003). The obtained results from measurements and statistical analysis (chapter three) provide a strong conviction for the assumed hypotheses.

This study showed that the arterial blood pressure (systolic and diastolic), pulse rate, and hearing threshold levels of workers before exposure is close for the various groups of workers, Table 4.2, 4.3, 4.8 and 4.10 show that the measured values are increased after exposure to noise. The strength of the results is good; Table 4.11 presents the correlation coefficients for the dependent variables, it can be seen that the change of the values is depending on the noise levels. From Table 4.4 and Table 4.8 we can see that the systolic blood pressure increased by 4.5 mmHg, while the diastolic blood pressure increased by 5.1 mmHg, the pulse rate increased by the value of 9.1 beats/minute. The hearing threshold levels also show an increase of 1.2 to 5.8 decibels.

The results of this study are similar to other studies, which give it high credibility. Other studies found similar results; Talbott EO, et al., (1999) showed that for noise difference of 83 dB(A) to 89 dB(A), there is a mean increase of 2.5 mmHg for systolic blood pressure, and a 2.5 mm Hg mean increase of diastolic blood pressure. Also (Van Kempen Elise E. M. M.,1 Kruize Hanneke,1 Boshuizen Hendriek C.,2 Ameling Caroline B.,1 Staatsen Brigit A. M.,1 & de Hollander Augustinus E.M. 1.(2002), estimated that relative increase per 5 dB(A) noise will result an increase of 1.14mmHg. Also (Fogari, Roberto a; Zoppi, Annalisa a; Corradi, Luca a; Marasi, Gianluigi a; Vanasia, Alessandro a; Zanchetti, Alberto b. (2001**)**, founds that there is a higher systolic blood pressure by a mean of 6 mmHg and an increase of diastolic blood pressure by a mean of 3 mmHg, and an increase in heart rate by 4.7 beats/minute for the workers whom works in noisy factories. From these studies it can be seen that the occupational noise can affect the cardiovascular system. From the previous studies it can be expected that these results can be reproduced if the measurements are to be carried out again.

There are different hypothesis and assumptions which were put to explain the preceding results. Harris, (1979) said that noise will cause a further increase in the stress reaction which will elevates blood pressure, this will increase cardiac oxygen demand which will in turn increase in the pulse rate. Another possible biological mechanisms for the relationship between noise and high blood pressure is activation of the sympathetic nervous system with release of epinephrine (Lenzi, P., Frenzilli, G., Gesi, M., Ferruei, MLazzeri. G., & Fornai, F., Nigro M. (2003).

We can conclude many notes from this study:

1- High levels of noise pollution can affect adversely the blood pressure (systolic and diastolic), pulse rate, and hearing threshold levels.

2-The noise pollution in industrial plants in Jenin region is very extensive, (from the sound level meter measurements), a large ratio of factories have noise pollution above 85 dB(A), with mean of 89.7 dB(A).

3- Most of the plants don't work with its full capacity, not all the machines are running; some plants even work with its half capacity, because of the political and economical conditions. Therefore, the problem is worst and the exact levels of noise are expected to be more than what have been measured.

4- Most of the workers, managers, and plants owners have an apparent unawareness of noise problem; they simply do not recognize that there is a problem from noise in the plants.

5- There are no safety procedures or shields or any procedures to protect from the danger noisy machines and devices.

6- Regulations are present (the Palestinian Environmental Law, (material 25), The Municipality local legislation). But the activation for these legislations is absent or neglected or simply unknown.

7- A wide portion of workforce works in the stonecutter field. The workers in this field will receive high levels of noise (from Table 4.1 the dB(A) for this field is very high, above 98 decibels) which considered dangerous ; as a result the workers health will be in reasonable danger.

8- Some hearing impairments are sometimes not easy to be noticed. There is a need to perform periodical tests to investigate these impairments.

The present situation of noise pollution problem in Jenin plants is bad and needs to be changed towards decreasing the high levels or protect the workers from facing these levels. This problem is found in a lot of areas and countries, even in the developed countries, there have been attempts to protect the workers. The solutions to these problems need the cooperation of all the parties involved.

There are many recommendations and actions (mainly from OSHA, WHO, and Engineering books and standards), which can be carried on to reduce or prevent the occupational noise problem in order to conserve workers health:

1- Educational and awareness of the noise problem will be helpful in reducing and limitation of the consequences. This is very important because there is a low level of public awareness on noise issues. As a result a very few at the top will take action.

2- Translocation the noisy plants away from the residential areas.

3- The Legislation must be obeyed and respected. Periodical visits by the inspectors will help in respecting and implementing the directions from the responsible authorities.

4- Reduce the emitting noise by shielding with acoustic barriers, this will help in absorbing or deflecting the noise.

5- Maintenance for the noisy machines will reduce the emitted noise.

6- The designing and construction process of plants and factories should take into account the possible emitted noise, and try to reduce it.

7- Periodic tests for the workers may help in determination the adverse effects of noise early.

8- Provide workers in noisy plants with noise protective equipment such as ear protectors.

9- Reduce the time workers exposed to noise.

10- Allowing enough spaces between machines.

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بســـم الله الرحمن الرحيم

جامعة النجاح الوطنية
كلية الدراسات العليا

تأثير الضوضاء على ضغط الدم, نبض القلب, ودرجة السمع عند عمال المصانع في مدينة جنين, فلسطين.

إعداد
عبد الناصر إسماعيل سلامة

إشراف
د. عصام راشد عبد الرازق
د. زيد قمحية

قدمت هذه الأطروحة استكمالا لمتطلبات درجة الماجستير في العلوم البيئية بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس, فلسطين.

2005

عند عمال المصانع في مدينة جنين, فلسطين.

إعداد

عبد الناصر إسماعيل سلامة

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د. عصام راشد عبد الرازق و د. زيد قمحية

الملخص

أظهرت هذه الدراسة العلاقة بين مستوى الضوضاء المهنية و كل من ضغط الدم(الانقباضي والانبساطي), نبض القلب, ودرجة السمع عند عمال المصانع في مدينة جنين/فلسطين. تم إجراء قياسات دقيقة لمستوى الضوضاء لدى المصانع, حيث تراوح مستوى الضوضاء بين (78.2 – 98.5) ديسيبل. ثم تم اختيار عينات عشوائية (15 مصنعا) لتمثل مستويات الضوضاء المختلفة. تم قياس ضغط الدم (الانقباضي والانبساطي), نبض القلب, ودرجة السمع على ذبذبات مختلفة عند عمال المصانع قبل التعرض للضوضاء وبعد (6-8) ساعات من التعرض للضوضاء.

وجد معامل ارتباط قوي (معامل ارتباط بيرسون) بين مستوى الضوضاء المهنية و كل من ضغط الدم الانبساطي, نبض القلب, ودرجة السمع على ذبذبات مختلفة عند عمال المصانع. نتيجة للتعرض للضوضاء ازداد معدل ضغط الدم الانقباضي بمقدار 4.5 مليمتر زئبقي, وازداد معدل ضغط الدم الانبساطي بمقدار 5.1 مليمتر زئبقي, وازداد معدل النبض بمقدار 9.1 نبضة/الدقيقة. كما قلت درجات السمع بمعدل يتراوح (1.2 – 5.8) ديسيبل.