PREVALENCE OF SENSORINEURAL HEARING LOSS AMONG ARMY WORKERS IN THE SMALL ARM AMMUNITION FACTORY, ORDNANCE DEPARTMENT

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This research was designed to study the effect of machinery noise in the small arm ammunition factory, ordnance department of 164 army workers. The type of noise in this factory was steady-state noise, ranging between 90.4-105.6 dBA.

The result of this research indicate that 15% of the army workers had normal hearing, whereas 5% had conductive hearing loss and 80% had sensorineural hearing loss. One hundred and thirty one army workers who had sensorineural hearing loss were divided into two groups: 77.1% had registered hearing loss and 22.9% had sensorineural hearing loss.

According to Wisuthipat's classification on registered hearing loss, most army workers with registered hearing loss (53.47%) had registered hearing loss type 1. Most of sensorineural hearing loss army workers had bilateral hearing loss (81.68%). For army workers who had unilateral hearing loss, there was no significance difference in number of left and right ear hearing loss, exhibiting 54.16% (n=13) and 45.84%(n=11) for left and right ear hearing loss respectively. Peak prevalence of hearing loss was found to be at 6,000 Hz (49.16%) and the mean hearing threshold at 6,000 Hz was found to be poorer than other frequencies.

Factors that affect hearing threshold include duration of exposure to noise, age of the army workers, working area, and gender. The result of this study showed that duration of exposure to noise and age of army workers were statisticaly significant and related to hearing threshold at all frequencies. It was significant that army workers who worked at area A(105.6 dBA) and area B(104.3 dBA) had poorer hearing threshold than army worker who worked at area F (90.4 dBA) at some frequencies. The result of this study significantly showed that male hearing threshold was poorer than those of sensorineural hearing loss for female army workers at some frequencies.

Results of this research will be useful in developing a hearing conservation program for all Royal Thai Army factories.

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ร.อ.หญิง สุภัทรี บุญพราหมณ์ : อุบัติการประสาทหูเสื่อมของคนงานทหารในโรงงานผลิตกระสุนปืนเล็ก กรมสรรพาวุธทหารบก (PREVALENCE OF SENSORINEURAL HEARING LOSS AMONG ARMY WORKERS IN THE SMALL ARM AMMUNITION FACTORY, ORDNANCE DEPARTMENT) คณะกรรมการควบคุมวิทยานิพนธ์ : ศิริพันธ์ ศรีวันยงค์, M.B.A., M.Sc., พ.อ.พงษ์เทพ หารชุมพล, M.A., มนต์ทิพย์ เทียนสุวรรณ, Ph.D. 84 หน้า. ISBN 974-04-1441-9

การศึกษาครั้งนี้ มีวัตถุประสงค์เพื่อศึกษาผลกระทบของเสียงรบกวนจากเครื่องจักรผลิตกระสุนปืนเล็กต่อการได้ยินของคนงานทหารในโรงงานผลิตกระสุนปืนเล็ก กรมสรรพาวุธทหารบก จำนวน 164 คน ลักษณะของเสียงในโรงงานเป็นเสียงประเภทเสียงที่ดังสม่ำเสมอ ซึ่งมีระดับความดังอยู่ในช่วง 90.4-105.6 เดซิเบล เอ

ผลการศึกษาพบว่า คนงานทหารที่มีการได้ยินปกติทุกความถี่ที่ตรวจพบร้อยละ 15 คนงานทหารที่มีความผิดปกติของหูชั้นนอกและ/หรือ หูชั้นกลาง พบร้อยละ 5 และ คนงานทหารที่มีประสาทหูเสื่อม พบร้อยละ 80 เมื่อนำคนงานทหารที่มีประสาทหูเสื่อมทั้งหมดจำนวน 131 คน มาจัดกลุ่ม พบว่า มีคนงานทหารที่ประสาทหูเริ่มเสื่อมจากเสียงในช่วงความถี่สูงกว่า 2,000 เฮิทซ์ ร้อยละ 77.1 และ มีคนงานทหารที่เป็นประสาทหูเสื่อมจากเสียง ร้อยละ 22.9

เมื่อแบ่งกลุ่มคนงานทหารที่มีประสาทหูเริ่มเสื่อมจากเสียงตามวิธีของอุษา วิสุทธิแพทย์ พบว่าส่วนใหญ่มีประสาทหูเริ่มเสื่อมแบบที่ 1 พบร้อยละ 53.47 และจากการศึกษาพบว่า คนงานทหารส่วนใหญ่จะมีประสาทหูเสื่อมทั้งสองข้างมากกว่ามีประสาทหูเสื่อมเพียงข้างเดียว โดยมีประสาทหูเสื่อมทั้งสองข้างคิดเป็นร้อยละ 81.68 และในคนงานทหารที่มีประสาทหูเสื่อมข้างเดียว พบการเสื่อมในหูซ้ายและหูขวาเป็นจำนวนใกล้เคียงกัน คิดเป็นร้อยละ 54.16 (จำนวน 13 หู) และ 45.84(จำนวน 11 หู) ตามลำดับ และส่วนใหญ่ร้อยละ 49.16 มีการเสื่อมการได้ยินมากที่สุดที่ความถี่ 6,000 เฮิทซ์ และค่าเฉลี่ยของระดับเริ่มการได้ยินของคนงานทหารที่ความถี่ 6,000 เฮิทซ์ เลวกว่าระดับเริ่มการได้ยินที่ความถี่อื่น

ปัจจัยที่มีผลต่อระดับเริ่มการได้ยินได้แก่ ระยะเวลาที่ทำงาน อายุของคนงาน แผนกที่ปฏิบัติงาน และ เพศ จากการศึกษาพบว่าระยะเวลาที่ทำงานและอายุของคนงานมีความสัมพันธ์กับระดับเริ่มการได้ยินในทุกความถี่ที่ตรวจ อย่างมีนัยสำคัญทางสถิติและพบว่าคนงานในแผนกเอ(เสียงดัง 105.6เดซิเบลเอ) และแผนกบี(เสียงดัง104.3เดซิเบลเอ)มีระดับการได้ยินเลวกว่าคนงานในแผนกเอฟ(เสียงดัง 90.4 เดซิเบลเอ)อย่างมีนัยสำคัญทางสถิติในบางความถี่และพบว่าในกลุ่มคนงานทหารที่มีประสาทหูเสื่อมนั้นเพศชายมีค่าเฉลี่ยของระดับเริ่มการได้ยินเลวกว่าเพศหญิงอย่างมีนัยสำคัญทางสถิติที่บางความถี่ จากผลการศึกษานี้จะเป็นประโยชน์ในโครงการอนุรักษ์การได้ยินของคนงานทหารในโรงงานต่างๆของกองทัพบกต่อไป

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CHAPTER I

INTRODUCTION

Occupational noise-induced hearing loss remains a common problem in industry. Prolonged exposure to high levels of noise typically results in sensorineural hearing loss secondary to inner ear damage. Damage may involve cochlear blood supply, sensory cell, nerve cells and supporting structures within the cochlea. Resulting hearing loss may be temporary or permanent, and these audiometric out comes have commonly been labeled temporary threshold shift (TTS) and permanent threshold shift (PTS), respectively. A third type of noise-induced hearing loss is acoustic trauma, which is typically associated with brief exposures to very high noise levels often demonstrating abrupt rise times. In general, the mechanisms of noise-induced hearing loss are thought to change with noise exposure levels and noise exposure type. Prolonged exposure to moderate levels of noise is thought to cause vascular change in the inner ear associated with TTS and PTS, while extreme noise levels are associated with immediate physical trauma to delicate inner ear structure. (i.e., acoustic trauma) (1)

The World Health organization has recommended noise threshold of 55 dBA during the day and 45 dBA during the night. These figures represent safe levels for the prevention of psychological and physical harm. The noise levels that exceed 85 dBA represent hazardous level. (Chu B, 1998).(2) The Thai Ministry of Interior has recommended that exposure to a 90 dBA noise is hazardous.(3)

In 1972, National Institute for Occupational Safety and Health inU.S.A. (NIOSH) published Criteria for a Recommended Standard: Occupational Exposure to Noise, which provided the basis for a recommended standard to reduce the risk of developing permanent hearing loss as a result of occupational noise exposure. The 1998 recommendations go beyond attempting to conserve hearing by focusing on preventing occupational noise-induced hearing loss (NIHL)

The NIOSH recommended exposure limit (REL) for occupational noise exposure (85 decibels, A-Weighted, as an 8-hour time-weighted average[85 dBA as an 8-hr TWA]) was reevaluated using contemporary risk assessment techniques and incorporating the 4000-hertz (Hz) audiometric frequency in the definition of hearing impairment.(4)

The NIOSH estimates that in 1992,approximately 30 million American workers were exposed to hazardous levels of occupational noise. Continual exposure to high noise levels damage and destroys hearing cell within the ear, making noise-induced hearing loss an irreversible impairment.

Hearing conservation programs are required by law for workers in industry setting where noise exposures equal or exceed 85 dBA.However noise-induced hearing loss cannot be reversed.(5)

Since the small arm ammunition factory's main mission is manufacturing the army's 5.56 x 45 mm ammunition models, the army workers in the small arm ammunition factory have been exposed to steady-state noise above the limits recognized from both institute (NIOSH and The Thai Ministry of Interior) to cause hearing damage without appropriate hearing protection. Therefore the researcher was interested in studying the effects of noise on the workers who work in the small arm ammunition factory.

Exposure to hazardous levels of noise is extremely expected in the factory's environment. The effects of overexposure to loud noise result in a slowly progressive increase in the auditory threshold. This research aimed to study the factors that may cause hearing losses among army workers in the small arm ammunition.

Purposes of this Research

1. To study the prevalence of sensorineural hearing loss among army workers in the small arm ammunition factory, ordnance department.
2. To study the level of noise in the small arm ammunition factory.
3. To study the characteristic of hearing loss that may be affected by loud noise.
4. To study the following the factors that may cause hearing loss among army workers in the small arm ammunition factory, ordnance department:

   4.1 duration of exposure to noise

   4.2 age

   4.3 level of noise at working area

   4.4 gender

Hypothesis of This Research

1.The prevalence of sensorineural hearing loss was higher among army workers in the small arm ammunition factory.

2. The level of noise in the small arm ammunition factory was high intensity of noise level.

3. The sensorineural hearing loss was greatest at 6,000 Hz. The poorest hearing threshold occurred at 6,000 Hz and sensorineural hearing loss tended to be bilateral rather than unilateral.

4. The shift of the hearing threshold of army workers with sensorineural hearing loss increased with duration of exposure to noise.

5. The shift of the hearing threshold of army workers with sensorineural hearing loss increased with age of workers.

6. Army workers in the area with higher level of noise developed sensorineural hearing loss more than those in the area with lower level of noise.

7. Hearing threshold of male workers was poorer than that of the female

Definition in This Research

RTA : Royal Thai Army

ARMY WORKERS : Army workers who were employed by the RTA to work at the small arm ammunition factory, ordnance department.

PURE-TONE AUDIOMETRY: The aim of pure-tone audiometry is to establish hearing threshold sensitivity across the range of audible frequencies important for human communication. Threshold sensitivity is usually measured for a series of discrete sinusoids or pure tone. The objective of pure-tone audiometry is to determine the lowest intensity of such a sinusoid that the listener can "just barely hear". (6)

TYMPANOMETRY : Tympanometry is the method used to determine how the eardrum and middle ear structures are working, one commonly referred to as the test of middle ear function. From tympanometry, can ascertain: whether there is fluid behind the eardrum in the middle ear space, how the eardrum is moving when sound strikes it, and if the middle ear muscles are working properly. Tympanometry is not a test of hearing but a test of middle ear function. It is possible to be completely deaf and still have normal tympanograms.(7)

AUDIOGRAM : Graph of hearing threshold levels as a function of frequency (ANSI S3.20-1995:audiogram).(8)

HEARING THRESHOLD LEVELS (HTL) : For a specified signal, amount in decibels by which the hearing threshold for a listener, for one or both ears , exceeds a specified reference equivalent threshold level. Unit, dB (ANSI S1.1-1994: hearing level; hearing threshold level).(8)

PERMANENT THRESHOLD SHIFT : Permanent increase in the threshold of audibility for an ear. Unit, dB (ANSI S3.20-1995:permanent threshold shift; permanent hearing loss; PTS).(8)

TEMPORARY THRESHOLD SHIFT : Temporary increase in the threshold of audibility for an ear caused by exposure to high-intensity acoustic stimuli. Such a shift may be caused by other means such as use of aspirin or other drugs. Unit, dB. (ANSI S3.20-1995: temporary threshold shift; temporary hearing loss).(8)

NORMAL HEARING : Conditions that the air conduction thresholds at 500, 1000, 2000, 3000, 4000, 6000, 8000 Hz are 25 dB or less (ANSI-1969)

CONDUCTIVE HEARING LOSS : This loss occurs when there is a problem with the outer and/or middle ear and sound are not transmitted properly. This type of hearing loss is usually treatable through medical intervention. If not, then a hearing aid is a appropriate option.(9) Using the audiometric criteria, the conductive hearing loss is diagnosed if the air conduction thresholds show a hearing loss but the bone conduction thresholds are normal. (10)

SENSORINEURAL HEARING LOSS : This loss occurs when there is damage to the inner ear mechanism (cochlear, vestibular system or auditory nerve). This is typically a permanent, non-medical type of hearing loss, and usually helped by amplification.(9) Using the audiometric criteria, the sensorineural hearing loss is diagnosed if both the air conduction thresholds and the bone conduction thresholds show the same amount of hearing loss. Conditions that the air conduction threshold are above 25 dB.(10)

MIXED HEARING LOSS : This loss occurs with a combination of sensorineural and conductive components.(9) Using the audiometric criteria, the mixed hearing loss is diagnosed if the bone conduction thresholds show a hearing loss and the air conduction thresholds show an even greater hearing loss. (10)

REGISTERED HEARING LOSS (Wisuthipat's classification)(12) : Conditions that the air conduction thresholds at 500, 1000, 2000 Hz are 25 dB or less and that the air conduction thresholds at 3000, 4000, 6000, 8000 Hz are above 25 dB. The registered hearing loss (R) is further divided into 5 patterns, namely

R1- Bilateral sensorineural hearing loss with a dip at 3K, 4K or 6KHz with better hearing at 8KHz..

R2- Unilateral noise-induced hearing loss.

R3- Bilateral high frequency hearing loss.

R4- Unilateral high frequency hearing loss.

R5- Unilateral noise-induced hearing loss and unilateral high frequency hearing loss

INTERMITTENT NOISE: Intermittent noise is defined as one or more short, transient, acoustical events that less than 0.5 seconds. Noise levels that are interrupted by intervals of relatively low sound levels.(8,13)

FLUCTUATING NOISE : Fluctuating noise is continuous but levels rise and fall more than 5 dB during a particular exposure period.(15)

STEADY- STATE NOISE : Steady-state noise could be described as continuous daily exposure in which the overall levels do not vary more than ±5 dB. Steady noise is a periodic or random variation in atmospheric pressure at audible frequency. It may be continuous, intermittent or fluctuating, with the sound level varying over a wide range. For example, high intensity steady noise is commonly found in the near field electrical generator sets; in machine shops, carpenter shops, and engine repair and testing shops; in any area where air-driven tool are used.(14)

IMPULSE NOISE : Also referred as impulsive or impact noise, or as blast overpressure such as that produced by weapons fire, punch presses and drop hammers. Impulse noise is characterized by a rapid rise time of not more than 35 milliseconds to a peak pressure. The total duration of a single impulse is not more than 500 milliseconds.(14)

The Expected Outcome of This Research

1. This research presents the prevalence of sensorineural hearing loss among army workers in the small arm ammunition factory.

2. This research will indicate the factors that may cause hearing loss.

3. This research can be guideline in developing a hearing conservation program for Royal Thai Army factory.

CHAPTER II

LITERATURE REVIEW

This chapter reviews some relevant topics in this research : anatomy and physiology of the human ear, type of hearing loss, degree of hearing loss,registered hearing loss, noise-induced hearing loss, type of noise, effect of noise on the inner ear, hearing loss due to noise exposure, presbycusis, noise-induced hearing loss in older adults, compound factor of noise-induced hearing loss, and hearing protectors.

1. Anatomy and Physiology of the Human Ear

The ear is the organ structure most sensitive to sound pressure change. The function of the ear is to transmit to the brain an accurate pattern of all sounds received from the environment, the relative intensity of these sounds, and the directions from which they emanate. The ear is divided into three major anatomical division: (a) The outer ear, (b) The middle ear, and(c) The inner ear.

The outer ear consists of two primary components, the pinna and the ear canal. The outer ear serves four primary functions. First, it protects the more delicate middle and inner ears from foreign bodies. Second, it boosts or amplifies high frequency sounds. For the ear canal of the adult, the resonant frequency is approximately 2,500 Hz, while that of the concha is roughly 5,000 Hz. The resonance of these cavities is such that each structure increases the sound pressure at its resonant frequency about 10-12 dB. Third, the outer ear provides the primary cue for the determination of the elevation of a sound's source. Fourth, the outer ear assists in distinguishing sounds that arise from in front of the listener from those that arise from behind the listener. The tympanic membrane stretches across the inner end of the external ear canal separating the outer ear from the middle ear.

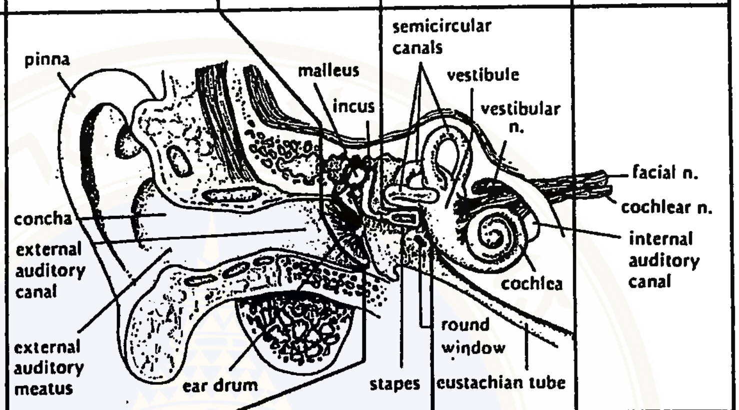
The middle ear is the tiny cavity in the temporal bone. The three auditory ossicles; malleus, incus and stapes form a bony bridge from the external ear to the inner ear. The bony bridge is held in place by muscles and ligaments, the tenser tympani muscle and the stapedius muscle. Contraction of both muscles increases the stiffness and the damping of the ossicular chain. The response latency of this muscle reflex varies from 25 to over 100 milliseconds; consequently, it operates too slowly to provide protection against brief, impulsive sounds shorter than about 20 milliseconds. The middle ear chamber is filled with air and open in the throat through the Eustachian tube. The Eustachian tube helps to equalize pressure on both sides of the eardrum.

The inner ear is a fluid-filled chamber divided into two parts: the vestibular larbirynth, with the functions as part of the body's balance mechanism, and the cochlea, which contains the hearing-sensing nerve. The human cochlea forms a somewhat cone-shaped spiral with 2 ¾ turns. There are three chambers in the cochlea, the scala media, scala vestibuli and scala tympani. The scala media is separated from the scala vestibuli above by Reissner's membrane and from the scala tympani below by the basilar membrane. The organ of corti runs longitudinally along the basilar membrane. It is made up of inner hair cell, outer hair cell, and various supporting cells. The organ of corti near the apex of the cochlea responds to low frequencies and near the base for higher frequencies. The organ of corti functions as the switchboard of the auditory system. The eight cranial or acoustic nerve leads from the inner ear to the brain, serving as the pathway for the impulses to the brain.

Sound creates vibrations in the air somewhat similar to the 'wave'. The outer ear collects these sound waves; and they are funneled down the external ear canal to the eardrum.

As the sound waves strike the eardrum, they cause it to vibrate. The vibrations are transmitted by mechanism action through the middle ear over the bony bridge formed by malleus, incus and stapes. These vibrations cause the membrane over the openings to the inner ear to vibrate, causing the fluid in the inner ear to set in motion. The motion of the fluid in the inner ear excites the nerve cells in the organ of corti, producing electrochemical impulses that are gathered together and transmitted to the brain along the acoustic nerve. As the impulses reach the brain, the sensation of hearing will be experienced. (16)

Figure 1 Anatomy of the human ear

Gross division	*Outer ear*	*Middle ear*	*Inner ear*	*Central auditory nervous system*
Anatomy				
Mode of operation	*Air vibration*	*Mechanical vibration*	*Mechanical, Hydrodynamic, Electrochemical*	*Electrochemical*
Function	*Protection, Amplification, Localization*	*Impedance matching, Selective oval window stimulation, Pressure equalization*	*Filtering distribution, Transduction*	*Information processing*

2. Type of hearing loss

There are five types of hearing loss that are named according to the area of the ear that is affected. They are conductive hearing loss, sensorineural hearing loss, mixed hearing loss, central hearing loss, and functional hearing loss.

A conductive hearing loss (CHL) is a reduction in hearing sensitivity due to a disorder of the outer and/or middle ear. This condition is usually medically treatable and reversible. Examples of possible causes of conductive hearing loss include: otitis media, impact cerumen, otosclerosis, etc. A conductive hearing loss has a maximum limit of approximately 60 dB HL (17)

A sensorineural hearing loss is a reduction in hearing sensitivity due to a disorder of the cochlea. Sensorinural hearing loss (SNHL) is caused by damage of inner ear, the auditory nerve, or both. Sensorineural hearing loss is not reversible through medical or surgical intervention. Examples include hearing loss due to aging (presbycusis), noise-induced hearing loss, etc. However in some cases of Meniere's disease, This disorder is characterized by a pathological change in the endolymph, which effectes the hair cells and which causes a reversible temporary threshold shift. (18)

A mixed hearing loss is a reduction in hearing sensitivity due to a combination of a disordered outer or middle and inner ear. Mixed hearing loss (MHL) usually included both conductive and sensorineural hearing loss in the same ear.

Central hearing loss is caused by a lesion that effects primarily the central nervous system from the auditory nuclei to the cortex. Some general diseases affect central auditory system such as encephalitis, vascular accident, brain tumors and infection etc.

Functional hearing loss is the type of condition in which the patient does not seem to hear or to respond to any acoustic stimuli. The handicap may not be caused by any organic pathology in the peripheral or central auditory pathways. The hearing difficulty may have and entirely emotional or psychological etiology. (19)

3. Degree of Hearing Loss

Degree of hearing sensitivity loss is commonly defined on the basis of the audiogram. Following is a general guideline for describing degree of hearing loss. Normal hearing is defined as audiometric zero, plus or minus two standard deviations of the mean. Thus, normal sensitivity range from –10 to +25 dB HL. All other classifications are based on generally accepted terminology. (20)

Table1 Degree of hearing loss

Degree of loss	Range in dB HL (500-2,000 Hz)
Normal	-10 to 25
Mild	25 to 40
Moderate	40 to 55
Moderately severe	55 to 70
Severe	70 to 90
Profound	>90

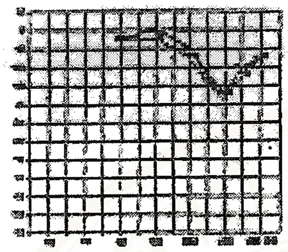
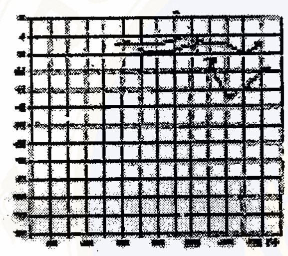
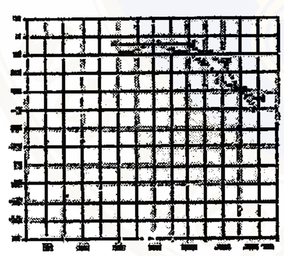
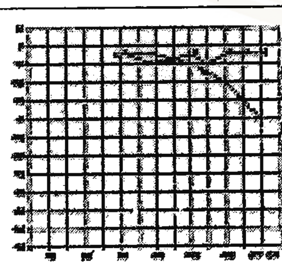
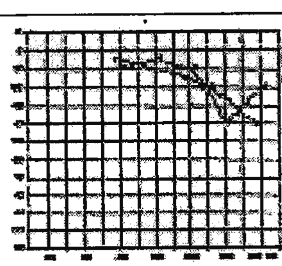
In terms of communication, the degree of hearing loss might be considerated as follows:

Mild	- has difficulty hearing faint or distant speech, even in quiet
Moderate	- hears conversational speech only at a close distance
Moderately severe	- hears loud conversational speech
Severe	- cannot hear conversational speech
Profound	- may hear loud sounds; hearing is not the primary communication channel

4. Registered hearing loss

Registered hearing loss is the condition that the air conduction thresholds at 500, 1000, 2000 Hz are 25 dB or less and the air conduction thresholds at 3000, 4000, 6000, 8000 Hz are above 25 dB. According to Wisuthipat's classification (12). This category consists of detailed analysis of noise-induced hearing loss as well as high frequency hearing impairment. Registered hearing loss was classified into 5 subgroups. (See table 2)

Table 2 Type of Registered hearing loss according to Wisuthipat's classification

Audiogram	Definition
	Registered type 1 (R1) Bilateral sensorineural hearing loss with a dip at 3K, 4K or 6K Hz with better hearing at 8K Hz.
	Registered type 2 (R2) Unilateral noise-induced hearing loss.
	Registered type 3 (R3) Bilateral high frequency hearing loss.
	Registered type 4 (R4) Unilateral high frequency hearing loss.
	Registered type 5 (R5) Unilateral noise-induced hearing loss and unilateral high frequency hearing loss.

5. Noise-Induced Hearing Loss

The Industrial Revolution's introduction of high levels of noise brought a great threat to the human auditory system. Hearing losses from intense noise exposure may be associated with brief exposure to high-level sounds, with subsequent partial or complete hearing recovery, or with repeated exposure to high-level sounds, with permanent impairment. Cases in which hearing thresholds improve after an initial impairment following noise are said to be the result of temporary threshold shift (TTS); irreversible losses are called permanent threshold shift (PTS).

A number of agents may interact with noise to increase the danger to hearing sensitivity. Although controversy continues over many aspects of noise-induced hearing loss, certain facts are generally agreed upon. Men appear to have a higher prevalence of hearing loss from noise than women do (Ewertson 1973; Surjan, Devald, and Palfavi 1973), perhaps because as a group they have greater noise exposure, both on the job and during leisure activities. Post-mortem electron microscope studies have shown loss of hair cells and their supporting structures in the basal end of the cochlea, and nerve degeneration in the osseous lamina (Johnson and Hawkins 1976). The hearing loss may be due to biological changes in the sensory cells, physical dislodging of hair cells during hyperacoustic stimulation, change in the cochlear blood supply with consequent alterations in the function of the stria vascularis, loss of the three rows of outer hair cells, rupture of Reissner's membrane, detachment of the organ of Corti from the basilar membrane, or to a variety of other causes. (21)

5.1 Prevalence of Sensorineural Hearing Loss

Amartayakul (22) was among the first to classify different types of noise-induced hearing losses based on audiometric configuration. He collected data from six industrial settings that were examined in 1969-1979. He concludes that although 4% of workers had typical noise-induced hearing loss, 30% of the workers had high frequency hearing loss. Unless attempts were made to reduce noise levels in the work areas, there was a high potential that these workers would suffer permanent hearing loss.

Harnchumpol (23) studied the effect of noise on hearing in Thai Military gun shooting advisers. The results showed 35.65% of the subjects had normal hearing, 64.35% of the subjects had sensorineural hearing loss.

Kasetvetin (24) studied the effect of gunfire impulse noise on hearing in 1213 Royal Thai Army cadets of Chulachomklao Royal Military Academy. The results showed 80.79% of the subjects had normal hearing, 18.97% of the subjects had sensorineural hearing loss, and malingering hearing loss were found in 0.8% of the subjects.

Wisuthipat (12) studied the effect of noise on hearing in 98 automobile workers. The results indicated that the 65.31% of the subjects showed various degrees of sensorineural hearing loss, 5.10% of the subjects had conductive hearing loss, and normal hearing were found in 29.59% of the subjects.

Pruegsanusak (25) studied the effect of gunfire impulse noise caused by gun firing on the hearing of 683 Royal Thai Air Force Cadets. The results showed 10.25% of them had sensorineural hearing loss, 0.58% had conductive hearing loss, 0.15% had congenital sensorineural hearing loss, and 89.02% had normal hearing. Most cadets who had sensorineural hearing loss showed high frequency hearing loss.

Nakropthai (26) studied the effect of noise on hearing in 59 workers of the Sriracha Pelletizing company. The results showed 52.30% of them had sensorineural hearing loss, 9.24% had conductive hearing loss, and 38.46% had normal hearing.

Daungrussami (27) studied the effect of aircraft noise on the hearing of 262 Royal Thai Air Force pilots. The results showed 36.20% of them had sensorineural hearing loss, 4.26% had conductive hearing loss, and 59.54% had normal hearing.

Walen, Prosek and Worthington (28) studied the prevalence of hearing loss in US Army Branches. The results showed 20-30% of them had sensorineural hearing loss.

Sataloff, Sataloff, Vassallo, and Menduke (29) investigated the effects of prolonged intermittent noise exposure on hearing. Two hundred and ninty-five workers who met the criteria were used as subjects for the study. Most subjects were exposed to jackhammer noise of 118 dBA. The results showed that occupational noise-induced hearing loss occurred in high frequencies first, then spreaded to lower frequencies as the years of employment increased.

Klockhoff et al. (30) studied the effects of hearing damage in 38,294 military service in Sweden. The results showed 33.9% of them had high frequency hearing loss.

Ylikoski (31) et al. studied the prevalence of hearing loss of 699 army officers with long-term exposure to gunfire noise. The results showed 224 (32%) of them had normal hearing. Most of subjects with hearing loss belonged to older age categories, and more than one-fourth of the officers under 30 years of age had a hearing loss.

Dempsey (32) investigated the effects of prolonged noise exposure on hearing of 76 workers. The results showed 69.74% of them had sensorineural hearing loss.

5.2 Configuration of Hearing Loss

It has been known for many years that prolonged exposure to high-intensity noise results in sensorineural hearing loss that is greatest between 3,000 and 6,000 Hz. The greatest loss usually occurs at 4,000 Hz. (33)

Harnchumpol (23) studied the audiogram of 115 gun-shooting advisers who had sensorineural hearing loss. The average hearing threshold of them at 4,000 Hz was statistically significant more than other frequencies.

Kasetvetin (24) studied the audiograms of 230 RTA cadets who had sensorineural hearing loss. The average hearing threshold of them at 6,000 Hz was statistically significant more than other frequencies. The study concluded that after being exposed to very loud noise, the sensorineural hearing loss was greatest at 6,000 Hz.

Taylor, Lampert, Pelmear, Hamstock, and Kershaw (34) determined noise levels and hearing thresholds of hammer workers, press operators, and normal subjects. The noise level for the hammers was 108 dBA and the press operating was 99 dBA. The results revealed hammer workers had hearing loss from 500 to 3000 Hz. The two groups showed similar threshold shift at 4000 to 6000 Hz.

Daungrussami (27) studied the audiograms of 262 Royal Thai Air Force pilots. In this research it was found that hearing loss occurred in the range of 3,000-8,000 Hz, with the ability to hear sounds at 6,000 Hz being most impaired.

Dempsey (32) investigated the effects of prolonged noise exposure on hearing of 76 workers. The results showed 69.74% of them had sensorineural hearing loss. Fourteen point forty seven percent had hearing loss at only 6,000 Hz.

Pelausa et al. (35) studied the noise-induced hearing loss in 134 Canadian military. The finding showed that a 6,000 Hz notch characterized audiograms of the 3 years recall, although mean threshold values were within normal.

Nakropthai (26) studied the sensorineural hearing loss in 59 workers of the Sriracha Pelletizing company. The average hearing threshold of them at 6,000 Hz was statistically significant more than other frequencies

Chun et al. (36) studied the sensorineural hearing loss of 51,856 workers in Canada. They were exposed to noise levels of 90 to100 dBA. The audiometric examinations showed high frequency hearing loss. The maximum threshold shift caused by noise was a notch at 6,000 Hz.

5.3 Side of Ear Affected

A characteristic of occupational noise-induced hearing loss is almost always bilateral. Audiometric patterns are usually similar bilateral. (37)

Wisuthipat (12) studied the effect of noise on hearing in 98 automobile workers. The results showed unilateral hearing loss more than bilateral hearing loss. Hearing loss in the right ear was more common than in the left ear.

Kasetvatin (24) studied the effect of gunfire impulse noise on hearing of 230 RTA cadets with sensorineural hearing loss. The results showed unilateral hearing loss more than bilateral hearing loss. Hearing loss in the left ear was more common than in the right ear.

Nakropthai (26) studied the noise-induced hearing loss in 59 workers of the Sriracha Pelletizing company. The results showed bilateral hearing loss more than unilateral hearing loss. Hearing loss in the left ear was more common than in the right ear.

Daungrussami (27) studied the audiograms of 262 Royal Thai Air Force pilots. . The results showed unilateral hearing loss more than bilateral hearing loss. Hearing loss in the left ear was more common than in the right ear.

Garcia and Garcia (38) studied audiometric value of 806 workers exposed to different levels of occupational noise. The results showed unilateral hearing loss more than bilateral hearing loss. Hearing loss in the left ear was more common than in the right ear.

Klockhoff et al. (30) studied the effects of hearing damage in 38,294 military service in Sweden. The results showed unilateral hearing loss more than bilateral hearing loss. Hearing loss in the left ear was more common than in the right ear.

Axelsson and Hamernik (39) studied the effects of acute acoustic trauma in 52 case. The results showed unilateral hearing loss more than bilateral hearing loss. Hearing loss in the left ear was more common than in the right ear.

Charakorn (40) reported hearing impairment in users with sport shooting. The results showed unilateral hearing loss more than bilateral hearing loss. Hearing loss in the right ear was more common than in the left ear.

Helmkamp (57) studied the occupational noise exposure and hearing loss characteristic of a Blue-collar population. The results showed bilateral hearing loss more than unilateral hearing loss.

6. Type of noise

The type of noise present in the industrial environment must also be considered. The noise may be steady-state, fluctuating, intermittent, or impulsive.

Steady-state noise can be described as continuous daily exposures in which the overall levels do not vary more than ±5 dB (Guignard, 1973).

Most frequently, noise encountered in industry is **fluctuating**, that is, the noise is continuous but levels rise and fall more than 5 dB during a particular exposure period.

An **intermittent noise** is described as being discontinuous. During the work period, the noise level may fall to low or nonhazardous noise levels between period of hazardous noise exposure.

Impulsive noise is characterized by a rapid rise time of not more than 35 milliseconds to a peak pressure. The total duration of a single impulse is not more than 500 milliseconds. A single impulse is usually heard as a discrete event occurring in otherwise quiet conditions or superimposed on backgrounds of steady state, ongoing noise. (41)

7. Effects of noise on the inner ear

Usually noise that has caused a loss of hearing has produced some sort of temporary or permanent damage to the inner ear, although middle ear damage and central nervous system change can also occur. Understanding what aspects of sound lead to inner ear damage is valuable in order to know how to avoid noise-induced hearing loss (NIHL). Obviously, damage to the hair cells would drastically affect the transduction processes and change the ability to hear. Unfortunately, it is the hair cells that appear to be most vulnerable to the overstimulation caused by acoustic stimuli that are called as noise.

The amount of inner ear damage is related to the exposure level of the noise, among other factors. Exposure to a very high level of noise can cause the type of inner ear destruction illustrated in Figure 2.1. In this example, the noise has destroyed the entire organ of corti in one section of the cochlea. It appears that the primary cause of the inner ear damage is that the elastic limits of the organ of corti were exceeded, and it was virtually torn apart. Noise with very high levels can also cause middle ear damage, such as rupture of the tympanic membrane. Lower noise levels cause less damage to the organ of corti .In Figure 2.2 destruction is confined to the outer hair cells, and the inner hair cells appear to be intact. For still lower levels of noise exposure, the outer hair cells may remain in place, but their stereocilia may swell, fuse, or otherwise be distorted, as shown in Figure 2.3. The stereocilia, tectorial membrane, and basilar membrane may all be structurally changed if the noise exposure is sufficiently intense. Since each of these structures plays an important role in the normal transduction of sound to neural impulses, their damage from noise exposure can produce significant hearing loss.

The effects of noise on hearing may be temporary or permanent. In mammals, if the hair cells are severely damaged, they will not recover or be replaced by new hair cells. The result is a permanent loss of hearing. However, recent work has shown that in some species (bird and fish) hair cells appear to regenerate after being destroyed from exposure to intense noise. It is not known if such regenerated hair cells function the same as the original hair cells or if regenerated hair cells allow these animals to recover their ability to hear. The reason why fish and bird hair cells regenerate and those of mammals do not is not yet understood.

If hair cell damage is slight, hair cells can recover, and hearing can return to normal. Mechanical destruction of the organ of corti caused by exceeding its elastic limits result in permanent loss of the hair cells. However, less severe hair cell damage is probably caused by various physiochemical processes such as those associated with the metabolic activity (which takes place in the stria vascularis) of the overexerted hair cell. It is also possible that moderate noise exposure alters the sensitive biomechanical connections of the inner ear, especially those that might be maintained by the motile responses of the outer hair cells. (42)

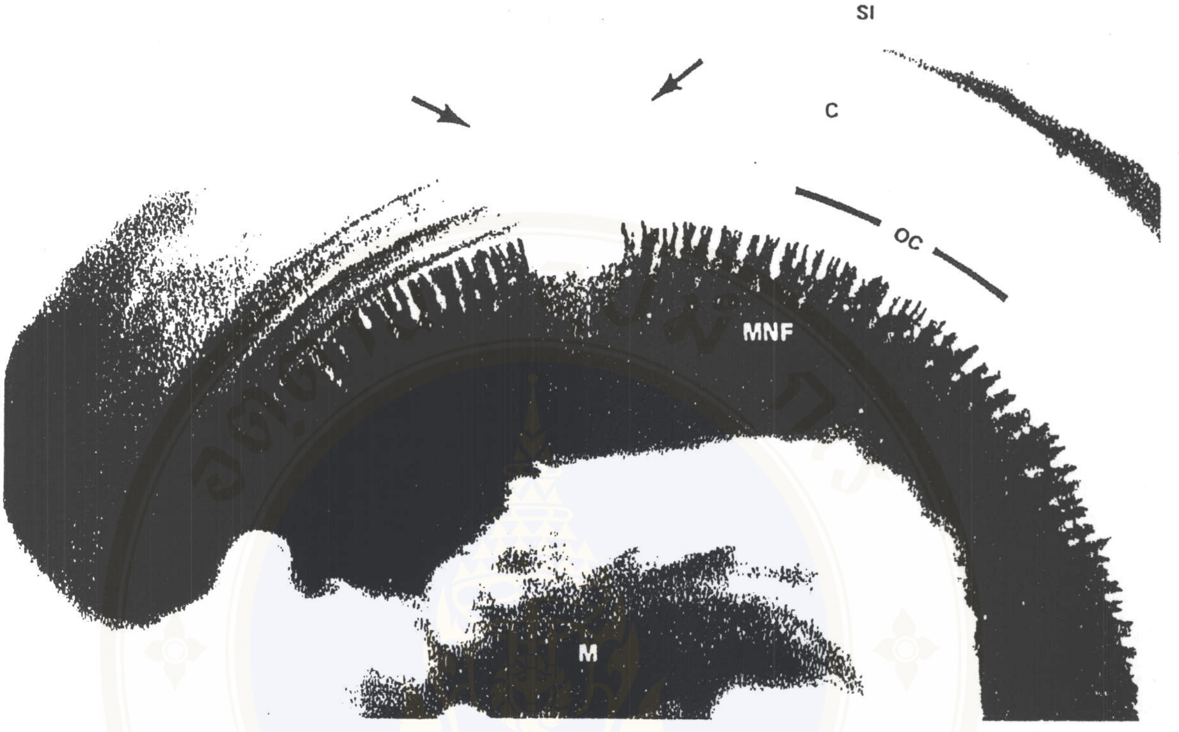


Figure 2.1 a Showed the organ of corti (OC) is missing due to a lesion or disruption caused by acoustic overstimulation, that is, a loud sound.

Figure2.1b Showed the outer hair cells are extremely distorted

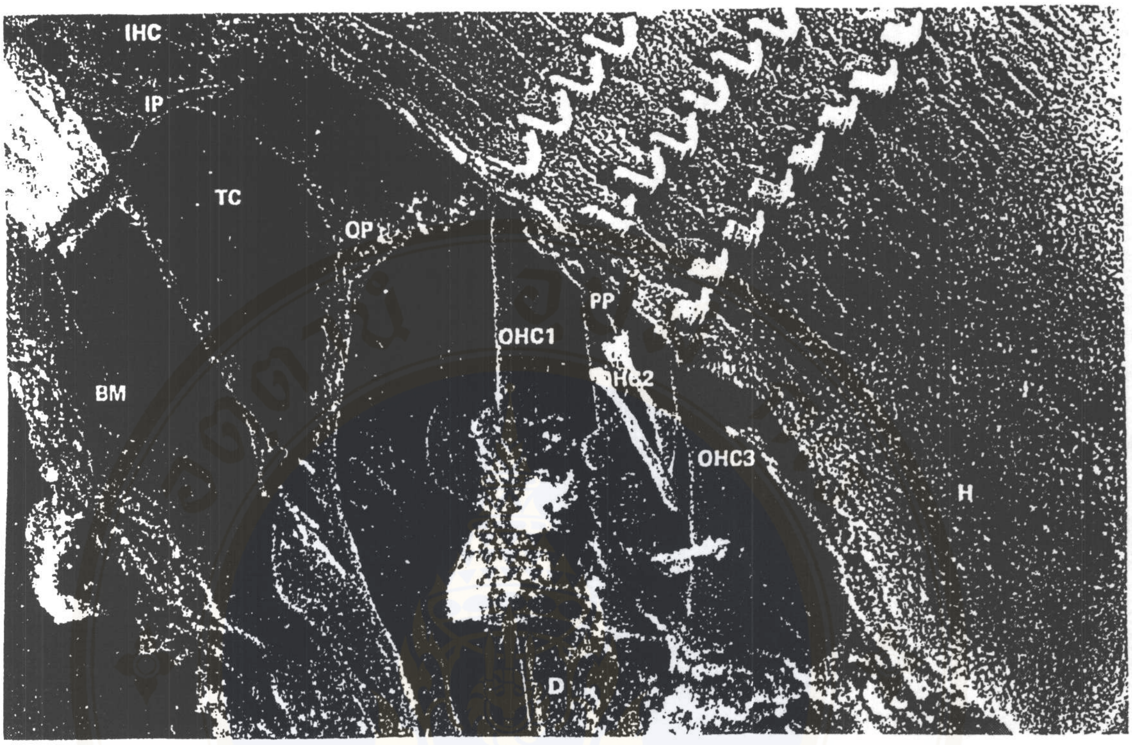


Figure 2.2 a Showed normal organ of Corti

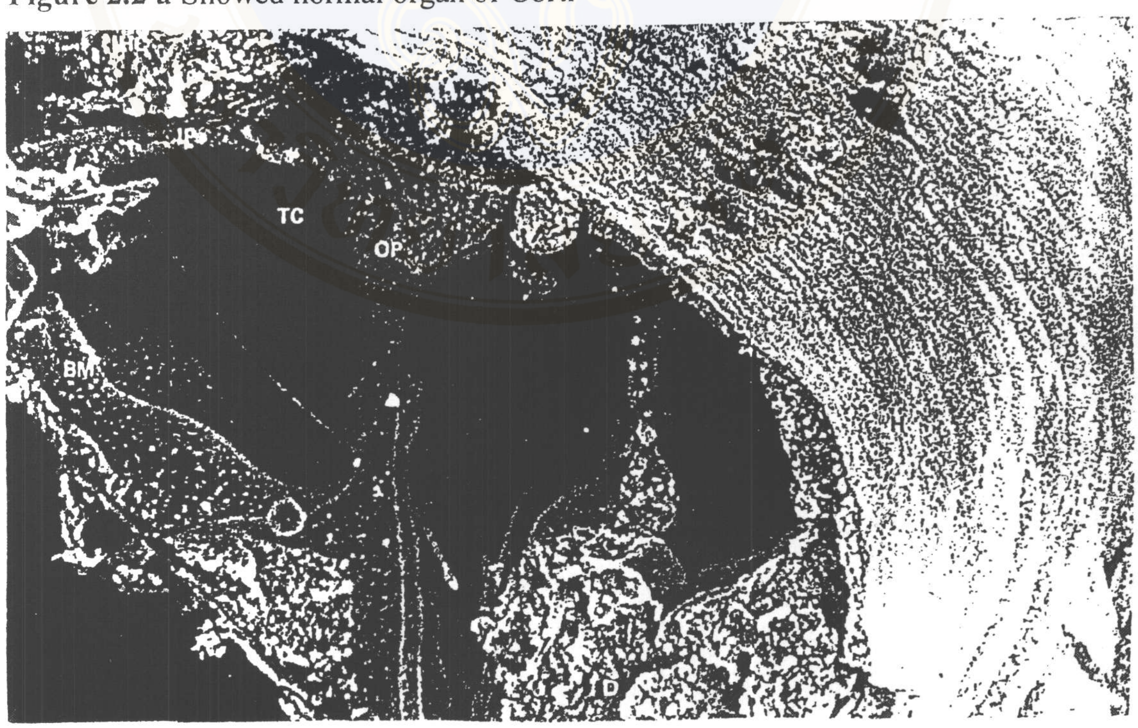


Figure 2.2 b Showed the effects of sound damage on the outer hair cells are clearly shown, as the cells are now missing.

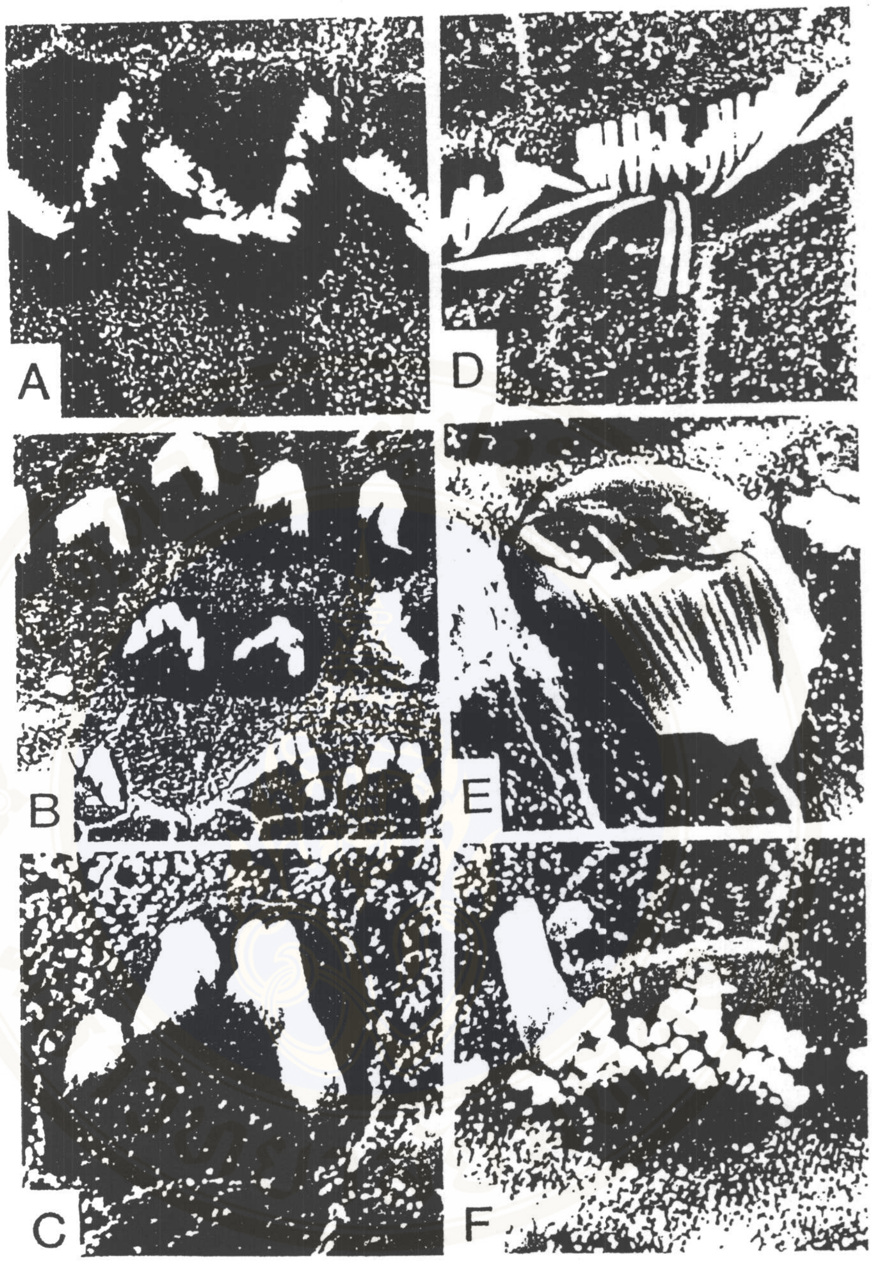


Figure 2.3 Various types of stereocilia distortion due to noise exposure. Micrographs A-C are OHCs and D-F are IHCs. (A) Missing OHC sterrocilia a few days after a pure-tone exposure. (B) Three rows of OHCs showing various degrees of fusing of stereocilia due to exposure. (C)Higher magnification of fused OHC stereocilia from B. (D) Floppy IHC stereocilia due to pure-tone exposure. This situation is probably not reversible. (E) Fusion of stereocilia. (F) IHC with many stereocilia missing and some remaining stereocilia fused due to noise exposure. This situation is not reversible.

8. Hearing loss due to noise exposure

Hearing may be effected by exposure to noise in several ways. One that has received the most attention is a change in hearing sensitivity or threshold. An increase in auditory threshold because of exposure to noise is called a **noise-induced threshold shift** (NITS). If over time, be in minutes, hours, or days, the threshold returns to its pre-exposure level, it is called a **noise-induced temporary threshold shift** (NITTS), or simply **temporary threshold shift** (TTS). If, however, the threshold dose not return to its pre-exposure value, it is called **a noise-induced permanent threshold shift** (NIPTS), or simply **permanent threshold shift** (PTS). In order to measure TTS or PTS, the threshold is measured twice, once before the exposure and then again after the exposure.

Even in PTS studies, after the exposure has stopped some hearing is restored. Thus, measures of hearing loss made immediately at the end of an exposure may consist of two components, a temporary component that will recover to some degree (that is, TTS) and a permanent component that remains for a lifetime (that is PTS). Hearing loss that combine TTS and PTS are called **compound threshold shifts** (CTS). (43)

9. Presbycusis

The term presbycusis refer to hearing loss associated with the aging process. In their recent report, the Committee on Hearing, Bioacoustic and Biomechanics (1988) defined presbycusis as the sum of hearing loss that results from several varieties of physiological degeneration including insults due to noise exposure, insults due to exposure to ototoxic agents, and results due to medical disorders as well as medical treatments. A number of scientists have advanced the possibility of a genetically determined predisposition to age-related hearing loss (Gilad and Glorig, 1979; CHABA, 1988).

Presbycusis is a decline in hearing as a part of the aging process. As a collective cause, it is the leading contributor to hearing loss in adults. Estimates suggest that from 25 to 40% of those over the age of 65 years have some degree of hearing impairment. The percentage increases to approximately 90% of those over the age of 90 years.(56) Normally in everyday life we hear 250 Hz up to 8,000 Hz so we do not become aware of any loss of hearing until frequencies below 8,000 Hz are affected. These frequencies are affected and first noticeable at the age of 50. (50)

Schuknecht (1964) postulated four distinct types of presbycusis on the basis of postmortem histologic findings in cochlear and retrocochlear structures. Each of four types of presbycusis, namely, sensory, neural, metabolic and mechanical is associated with a particular audiometric pattern; however, the relative frequency of each type of presbycusis is unknown. Similarly, although each form of presbycusis is associated with distinct pathological changes and audiometric pattern, varying combination of the four type of presbycusis and their audiologic manifestations do emerge (Gulya, 1991). Finally, the exact mechanism of loss for each of Schuknecht's type of presbycusis is still a subject of considerable debate among researchers.

The first type is named " Sensory presbycusis". Sensory presbycusis is characterized by hair cell loss and atrophy of the auditory nerve in the basal turn of the cochlea. The degenerative change tend to begin in middle age and progress slowly. It is manifested by a steeply sloping, high-frequency hearing loss with a proportional reduction in word recognition ability.

The second type is named " Neural presbycusis". Neural presbycusis is associated with primary degeneration of neurons and nerve fibers, with the greatest loss in the basal cochlea (Schuknecht, 1964). Neural presbycusis is typified by a loss of speech recognition ability that is out of proportion with hearing loss for puretone (White and Regan, 1987). The term phonemic regression, coined by Gaeth (1948), implies a disproportionate loss of speech understanding ability relative to the audiogram.

The third type is named "Metabolic presbycusis". The pathology of metabolic or strial presbycusis involves atrophy of the stria vascularis (Schuknecht, 1964). The functional manifestation of metabolic presbycusis is a flat audiogram with equal hearing loss across frequencies. Speech understanding ability tends to remain intact despite the puretone loss (White and Regan, 1987).

The fourth type is named "Mechanical presbycusis". Mechanical or cochlear-conductive presbycusis involves stiffening of the basilar membrane which interferes with sound transmission within the cochlea (Schuknecht, 1964). The hearing loss is slowly progressive, with a sloping configuration.

Although the changes in the auditory system associated with age are most pronounced in the inner ear and central auditory pathway, the structures of the outer and middle ears are susceptible to degeneration, as well. Rosenwasser (1964) noted structural changes in the tissue and skin lining the external auditory meatus which often manifest as cracking or bleeding of the skin. While these changes are of little functional significance, they are source of annoyance to older person wearing hearing aids. The ceruminal glands in the external auditory canal reportedly atrophy and undergo decreased activity (Regan and White, 1987). Clinically, these changes are often manifested by excessive accumulation of cerumen in the ears of older persons.

Covell (1952), Etholm and Belal (1974), and Rosenwasser (1964) reported age-related changes within structure of the middle ear. Specifically, the tympanic reportedly undergoes stiffening, the incudomalleal and incudostapedial joints of the ossicles undergo progressive degeneration, and the tensor tympani and stapedius muscle atrophy with age (Etholm and Belal, 1974; covell, 1952). Although the impedance characteristics in the middle ear, hearing sensitivity is not. (44)

10. Noise-Induced Hearing loss in Older Adults

The inner ear of older adults may also be susceptible to degeneration from exposure to excessive noise. This degeneration associated with the hair cells in the lower basal turn of the cochlea is distinct from deterioration due to "pure" presbycusis. The audiometric configuration associated with noise exposure, however, is difficult to separate from the patterns typically attributable to age (CHABA, 1988). Excessive noise exposure can present audiometrically as a loss of pure-tone sensitivity in the regions ranging from 3000-6000 Hz or as a steeply sloping high-frequency hearing loss. Rosen, Bergman, Plester, Mofty and Sati (1962) reported that environmental factors, such as living in a noise-free versus an industrialized society, can influence the extent of the high frequency hearing loss that emerges in older persons. Individuals living in a noise-free environment have better hearing in the high frequency than persons living in industrialized societies (Rosen et al., 1962). The extent to which hearing loss in older persons is attributable to noise rather than age cannot be predicted from the audiogram at this time. There is, however, support for the observation that age and exposure to noise can have a synergistic effect (Moscicki al., 1985). (45)

11. Compound Factor of Noise-Induced Hearing loss

11.1 Duration of exposure

The American College of Occupational Medicine Committee defined occupational noise-induced hearing loss as a slowly developing hearing loss over a long period (several years) as the result of exposure to continuous or intermittent loud noise (46). The level of hearing loss is associated with duration of exposure. (47)

Kasetvetin (24) studied the effect of impulse noise on the hearing of RTA cadets. The results showed the Prevalence of sensorineural hearing loss was significant with the number of years that the cadets spent in the academy.

Chavalitskulchai, Kongmuang, and Sangrrattanagul (48) studied the hearing loss of taxtile workers who were exposed to steady state noise. The noise level was more than 90 dBA. There was a direct correlation between hearing loss and duration of exposure.

Nakropthai (26) studied the effect of noise on hearing in 59 workers of the Sriracha Pelletizing company. The results showed the prevalence of sensorineural hearing loss was significant with the duration of employment.

Sataloff, Sataloff, Vassallo, and Menduke (29) investigated the effects of prolonged intermittent noise exposure on hearing. Two hundred and ninty-five workers who met the criteria were used as subjects for the study. Most subjects were exposed to jackhammer noise of 118 dBA. The results showed that occupational noise-induced hearing loss occurred in high frequencies first, then spreaded to lower frequencies as the years of employment increased.

11.2 Age

The general aging process affects all parts of the body, and the ear is no exception. Presbycusis actually begins in childhood as a progressive loss of hair cells and nerve fibers within the inner ear. This process starts in the highest frequency regions and gradually progresses to the speech range. When bilateral, symmetrical, sloping, high-frequency sensorineural hearing loss is identified in elderly persons, presbycusis is likely. (49)

Tawin (50) studied the prevalence of hearing loss in Thai with various age groups. Nineteen percent of the subjects hearing loss were in the 50-59 year age group and 36% were in 60-69 year age group. The results showed a tendency for hearing loss increasing with age.

Nakropthai (26) studied the effect of noise on hearing in 59 workers of the Sriracha Pelletizing company. The results showed the prevalence of sensorineural hearing loss was significant with age of workers.

Chavalitskulchai, Kongmuang, and Sangrrattanagul (48) studied the hearing loss of taxtile workers who were exposed to continuous steady noise. The noise level was more than 90 dBA. There was a direct correlation between hearing loss and age.

Rop, Raber, and Fischer (51) studied the effects of noise exposure on workers in different age groups. The outcome of the study indicated that the amount of hearing loss increased with age.

11.3 Gender

The prevalence of hearing impairment from noise exposure is greater in males than females. (52)

Szanto and Ionescu (53) compared the audiometric test results of male and female workers. The study concluded the hearing loss was more pronounced in males than in females.

Nakropthai (26) studied the effect of noise on hearing in 59 workers of the Sriracha Pelletizing company. The result showed that hearing sensitivity decline in men than women.

Rop, Raber, and Fischer (51) studied the effects of noise exposure on workers in different age groups. For the same age level, women had less hearing loss than men for a comparable intensity and duration of exposure.

11.4 Intensity

The World Health Organization (WHO) recommended hazardous noise: an 8 hours equivalent continuous A-weighted sound level equal to or greater than 85 dBA, or intermittent noise above 115 dBA, and impulse or impact noise above 140 dBA peak SPL (52).

The levels that exceed 85 dBA represent hazardous level. (Chu B, 1998).(2) The Thai Ministry of Interior has recommended that exposure to a 90 dBA noise is hazardous. (3)

Wisuthipat (12) studied noise-induced hearing loss in 98 automobile workers. The studied concluded the noise-induced hearing loss occurred when exposed to noise of 73-99 dBA.

Nakropthai (26) studied the effect of noise on hearing in 59 workers of the Sriracha Pelletizing company. The result showed that workers in the higher noise area (90-95 dBA) developed noise-induced hearing loss more frequently than in the lower noise area (65-85 dBA).

Daungrussami (27) studied noise-induced hearing loss in 262 Royal Thai Air Force pilots. She found the usually exposure of noise in the cockpit and near the aircraft averaged 95 to 115 dBA, as a damage level.

ANSI, in 1954 (56) studied the hearing threshold shift in 7,000 industrial workers and reported that there was threshold shift of 9 dB in workers who exposed to 80 dBA noise level and there was threshold shift of 15 dB in workers who exposed to 95 dBA noise level.

Szanto and Ionescu (53) studied occupational hearing loss in workers. The studied concluded the occupational hearing loss occurred when exposed to noise of 98 dBA

11.5 Other Condition

Furthermore, an individual's susceptibility to noise-induced hearing loss may result from numerous cofactors such as ear's disease, hereditary diseases, nonhereditary diseases, smoking, drugs, habit and others. (54)

12. Hearing Protectors

The industrial hearing conservation program is established to prevent noise-induced hearing loss. This can be accomplished by reducing the noise exposure. The best method for this reduction is to prevent the noise generation at the source. When this not possible, the next most desirable method is to reduce the opportunity for the employee to be exposed to noise though administrative controls. There will be many situations in which neither of these solutions to the noise problem is possible. Under these conditions, the method of choice would be to provide hearing protectors.

An effective hearing protector serves as a barrier between the noise and the inner ear, where the noise-induced damage occurs. Hearing protectors usually take one of two forms: the earmuff, which is worn over the external ear, helmet, which is worn over the external ear and provides an acoustic seal against the head; or earplugs, which seal the entrance to the external ear canal. The protection provided by a hearing protector depends on its design and on the physical characteristics of the person wearing the protector.

It is impossible to totally isolate the inner ear from noise by means of a hearing protector. Sound energy can reach the inner ears of person wearing protectors by three different paths:

1. By passing directly to the cochlea through vibration of the bones and tissues of the skull (bone conduction);

2. By vibration of the hearing protector itself, which generates sound in the ear canal; or

3. By passing through leaks in the hearing protector, or around the protector because of poor fit.

The absolute limits of attenuation provided by a hearing protector depend on the sensitivity of the bone conduction pathway.

Earplugs

There are many kinds of protectors on the market. The insert type of protector, or earplug, could be semi-permanent, molded of soft rubber or soft plastic material that is sized. No single-size molded earplug has been found that would fit the large range of ear canal size and shapes. Most of the accepted molded earplugs come in four or five different sizes.

Earplugs may also be malleable and made of such material as cotton, paper, wax, glass wool, silicone putty, or slow-recovery foams. These plugs, which can be shaped by wearer, are usually made of nonporous, easily formed materials, and they are capable of providing attenuation that compares favorably with other forms of hearing protectors. The malleable earplugs are usually designed for short-term use and are frequently disposable.

Earmuffs

Most of the muff protectors are similar in design. The protector ear cups are usually formed of a rigid, dense, imperforate material. These hard shells are fitting into soft, pliable seals, generally made of a smooth plastic envelope filled with foam or some fluid material. The cup encloses a volume of air that is directly related to low-frequency attenuation. The inside of the ear cup is partially filled with material that absorbs high-frequency resonant noises.

Selection Factors

Most protective devices available commercially will provide sufficient attenuation to offset the hazardous noise exposures typically found in industrial environments. The chief problem has been in developing motivation for employees to wear hearing protectors. Experience has shown that no one type satisfies all employees. It is therefore a good practice to stock more than one variety of protectors.

There are advantages and disadvantages to both muff and insert types of hearing protectors (Sataloff and Michael, 1973).

Advantages of earplugs

1. Small and easily carried;
2. Can be worn conveniently;
3. More comfortable to wear in hot environments;
4. Convenient to use when the head of wearer must be in close, cramped quarters;
5. Cost in generally significantly less than earmuffs.

Disadvantages of insert-type protection

1. The semipermanent type and molded hearing protectors require more time and effort to fit;
2. The amount of protection provided by an earplug is generally less and varies considerably among wearers;
3. Can become dirty and unsanitary through use;
4. Difficult to see at a distance, making it difficult to ensure that employees are wearing them;

5. Cannot be worn by individuals with external and middle ear infections.

Advantages of Muff-type protectors

1. A single size will fit most heads;
2. Usually more readily accepted by employee than earplugs;
3. Generally more comfortable than plugs;
4. Not as easily misplaced or lost as earplugs.

Disadvantages of Earmuffs

1. In general, more expensive than insert protectors;

2. Muff protection depends on the spring force of the headband; through usage, the force may be considerably weakened, and the protection significantly reduced.

These various kinds of hearing protectors afford the maximum protection in the higher frequencies above 1000 Hz. Earplugs, helmets or earmuffs may attenuate steady noise from approximately 15-20 dB in the lower frequencies to approximately 35 dB in the higher frequencies. If the insert and the muff types are combined, a maximum attenuation of about 50 dB can be realized under ideal conditions. It is fortunate that hearing protectors give most efficient attenuation in the higher frequencies, since noise in these frequencies is most harmful to hearing. (55)(18)

CHAPTER III

MATERIALS AND METHODS

Subjects

The sample group consisted of 164 RTA workers in the small arm ammunition factory, ordnance department. There were 130 males and 34 females. The age ranged from 25-60 years. The duration of exposure to noise ranged from 1-41 years. There was no baseline audiogram among these subjects. The army workers never received counseling concerning protection. Most of them (n =150, 91.46 %) had never used hearing protector, whereas fourteen of the army workers (8.54%) sometimes used dry cotton as hearing protector. None of them used hearing protector all work-time.

The criteria for selection the subjects were as the following:

1. Subjects were the workers in the small arm ammunition factory, ordnance department.

2. Subjects had a rest period of at least 48 hours from work period. This time was sufficient for recovery from temporary threshold shift (TTS).

3. The subjects had no conductive and / or mixed hearing loss.

Instruments

1. Test Room

All tests were performed in a quiet room that met ANSI S1.11-1971 (11)

Table 3 Maximum allowable octave-band sound pressure levels for audiometric test rooms.(Industrial or General Purpose)

Octave-band center frequency (Hz)	250	500	1000	2000	4000	6000	8000
Sound pressure level (dB)	40	40	40	47	57	62	67

2. Immittance Audiometer

Immittance audiometric test (Ampliad Model 775 Type 2-IEC 1027, according to ISO 389 and ANSI S3.39) was conducted to confirm the status of the middle ear condition. The test consisted of tympanogram, static compliance, and acoustic reflex.

3. Audiometer

Audiometric test was carried out by using Madsen Electronics audiometer model Midmate 602 which was calibrated to American National Institute Standard (ANSI,1969)

4. Otoscope

Otoscopic examination was conducted by the researcher to ensure that there was no earwax present.

5. Sound level meter

The small arm ammunition factory's noise was measured by using a sound level meter that met ANSI standard (S1.4-1983, Type 1), Quest Electronics model 1800.

6. Questionnaire

The questionnaire included questions regarding family and personal history of hearing loss, a history of previous noisy jobs, present noise exposure job and noisy hobbies including the use of gunfire, loud music, woodworking as well as noisy activities, routine use of hearing protection on the job, and current medical complaints. All the questions were designed according to the questionnaire developed by Ramathibody Hospital.

Procedure

1. Noise measurement

The small arm ammunition factory noise levels were measured by using a sound level meter in order to study the noise in the working environment. Noise measurement was performed in following orders:

1.1 Noise survey

The researcher performed noise survey to evaluate general information on the small arm ammunition factory, for example, number of workers in the factory, number of divisions in the factory, intensity of noise level estimation, and planning for noise measurement.

1.2 Noise measurement

Noise measurement was performed, using sound level meter, at the level of army workers' ear. The distance between sound level meter and army workers' ear was one meter. The intensity of noise level was measured three times at each area and the mean intensity of noise level was recorded in zone A to zone F, respectively.

2. Questionnaires

The questionnaires were filled out by interviewing the army workers. The questions consisted of medical history, previous, and current noise exposure information.

3. Hearing measurement

Before pure tone audiometric evaluation and acoustic immittance measures were conducted, all army workers were performed an otoscopic examination to exclude abnormal otologic findings such as inflammation of external canal, discharge, abnormal eardrum or excessive cerumen.

The audiometric evaluation was then scheduled for the subjects on Monday morning prior to starting their work in the small arm ammunition factory. The purpose was to prevent contamination of temporary threshold shift. Each army worker had a rest period of at least 48 hours from work period. This time was sufficient for recovery of temporary threshold shift (OSHA, 1981).

All subjects were administered with pure tone audiometry. The hearing test consisted of air and bone conduction test. The auditory threshold was determined by descending technique. The orders of test frequency were as follow: 1000, 1,500, 2000, 3000, 4000, 6000, 8000, and 500 Hz. The hearing threshold was retested at 1000 Hz for test reliability. Masking was used when there was a difference of 40 dB or more in hearing acuity between the two ears.

Bone conduction was determined after completing air conduction threshold. Bone conduction threshold was determined at frequency of 500, 1000, 1500, 2000, 3000 and 4000 Hz by using the same procedure as air conduction test. The masked bone conduction threshold for the ear should be obtained whenever the air-bone gap in the test ear exceeded 10 dB.

An immittance test was administered to the army workers. Only those who had type A tympanogram were included in this study and exhibit normal acoustic reflex threshold (90 dB) at frequency of 1,000 Hz. (20)

The statistical Analysis

In this study, the statistical package SPSS for windows was used to analyze the data as followings:

1. Number and percentage were used to study the prevalence of hearing loss, frequency of hearing affected by noise and ear affected.

2. Mean and standard deviation were used to compare the mean hearing threshold.

3. T-test was used to compare the mean different between sex and working area.

4. Pearson's correlation coefficient was used to study the relationship between duration of exposure to noise and hearing threshold, the relationship between age of workers and hearing threshold.

CHAPTER IV

RESULTS

The purpose of this research was to study the nature of hearing loss among army workers in the small arm ammunition factory, ordnance department. The results of this study were described in seven parts as follow 1) prevalence of hearing loss 2) level of noise in the small arm ammunition factory 3) frequency of sensorineural hearing loss and side of ear affected 4) The relationship between duration of exposure to noise and hearing threshold 5) The relationship between age of workers and hearing threshold 6) The relationship between working area and hearing threshold 7) The relationship between sex group and hearing threshold

1. Prevalence of Hearing Loss

One hundred and sixty four army workers were tested with pure tone audiometry and tympanometry. The prevalence of hearing loss was showed in table 4 the results indicated 15 % (25 army workers) of the total workers had normal hearing; 5 % (8 army workers), conductive hearing loss; and 80 % (131 army workers), sensorineural hearing loss. No mixed hearing loss was observed in this study.

Table 4 The number and percentage of type of hearing

Type of Hearing	Number	Percent
Normal hearing	25	15
Conductive hearing loss	8	5
Sensorineural hearing loss	131	80
Total	164	100

One hundred and thirty one army workers who had sensorineural hearing loss were divided into 2 groups. The prevalence of sensorineural hearing loss was showed in table 5. The results indicated 77.1 % (101 army workers) had registered hearing loss (hearing loss at high frequencies); 22.9 % (30 army workers), sensorineural hearing loss (hearing loss at all frequencies).

Table 5 The number and percentage of sensorineural hearing loss

Type of Hearing Loss	Number	Percent
Sensorineural hearing loss (all frequencies)	30	22.9
Registered hearing loss (high frequencies)	101	77.1
Total	131	100

Type of registered hearing loss was classified into the five groups. (12) The data from table 6 showed 53.47 % (54 army workers) had registered hearing loss type R1; 19.80% (20 army workers), registered hearing loss type R2; 9.90%(10 army workers), registered hearing loss type R3; 2.97%(3 army workers), registered hearing loss type R4; and 13.86% (14 army workers), registered hearing loss type R5.

Table 6 The number and percentage of registered hearing loss

Type of Registered Hearing Loss	Number	Percent
R1	54	53.47
R2	20	19.80
R3	10	9.90
R4	3	2.97
R5	14	13.86
Total	101	100

2. Level of Noise in the Small Arm Ammunition Factory

The small arm ammunition factory was divided into 6 areas, namely area A, B, C, D, E, and F.

Area A: Bullet's head preparation section

Area B: Cartridge case preparation section

Area C: Gunpowder filling section

Area D: Ammunition make-up section

Area E: Checking section

Area F: Packing section

Intensity of noise level in the small arm ammunition factory was at average of 90.4-105.6 dBA and type of noise was steady state noise.

Table 7 showed intensities of the small arm ammunition factory's noise distributed by area groups.

Table 7 The small arm ammunition factory's noise.

Location	Zone A	Zone B	Zone C	Zone D	Zone E	Zone F
Noise levels (dBA)	105.6	104.3	103	102.6	99.4	90.4

3. Frequency of Sensorineural Hearing Loss

3.1 Level of Hearing Loss by frequency

The mean and standard deviation of hearing threshold in each frequency from 500 to 8,000 Hz of 131 army workers (238 ears) were analyzed as showed in table 8. The results showed the severity of hearing loss occurred at 6,000 Hz, 4,000 Hz and 8,000 Hz respectively. The derived audiogram pattern was characterized to the similar path of those who were classified as registered hearing loss.

Table 8 Mean and standard deviation of hearing threshold distributed by frequencies.

Frequency (Hz)	500	1000	1500	2000	3000	4000	6000	8000
Mean	25.99	23.72	24.73	22.35	32.06	39.75	44.50	36.51
SD	9.05	10.11	11.37	13.16	15.01	16.28	16.72	20.84

Figure 3 showed composite audiogram that was plotted from mean hearing threshold in each frequency from 500 to 8,000 Hz. Hearing impairment was found at 500, 3,000, 4,000, 6,000 and 8,000 Hz. The mean hearing threshold at 8,000 Hz was better than at 6,000 Hz.

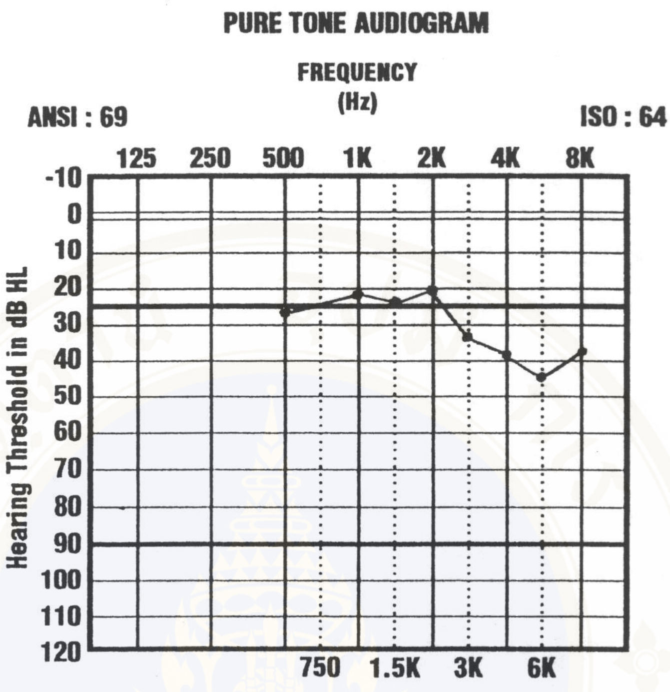


Figure 3 Composite audiogram by mean hearing threshold of sensorineural hearing loss army workers.

3.2 Notch of Hearing Loss

To study the hearing threshold at 500-8,000 Hz of 131 army workers (238 ears) were analyzed. The sensorineural hearing loss was greatest at 6,000 Hz.

Table 9 showed 49.16% (n=117) of the army workers had notch of hearing loss at 6,000 Hz, 28.57% (n=68) had notch of hearing loss at 4,000 Hz, 20.59% (n=49) had notch of hearing loss at 8,000 Hz, and 1.68% (n=4) had notch of hearing loss at 3,000 Hz respectively.

Table 9 The number and percentage of notch of hearing loss distributed by frequency

Frequency (Hz)	Number	Percent
500	0	0
1,000	0	0
1,500	0	0
2,000	0	0
3,000	4	1.68
4,000	68	28.57
6,000	117	49.16
8,000	49	20.59
Total	238	100

3.2 Side of Ear Affected

One hundred and thirty-one sensorineural hearing loss army workers were divided into unilateral and bilateral hearing loss. Table 10 showed the number and percentage of army workers with unilateral and bilateral hearing loss. There were 18.32% (n=24) of unilateral hearing loss and 81.68% (n=107) of bilateral hearing loss.

Table 10 The number and percentage of army workers with unilateral and bilateral hearing loss

Side of Ear Affected	Number	Percent
Unilateral	24	18.32
Bilateral	107	81.68
Total	131	100

For army workers who had unilateral hearing loss, 45.84% (n=11) exhibited right ear hearing loss, and 54.16% (n=13) exhibited left ear hearing loss as shown in table 11

Table 11 The number and percentage of army workers with right and left ear affected.

Side of Ear Affected	Number	Percent
Right ear	11	45.84
Left ear	13	54.16
Total	24	100

4. The Relationship between Duration of Exposure to Noise and Hearing Threshold

Pearson's correlation coefficient was used to analyze the correlation between duration of exposure to noise and mean hearing threshold from 500 to 8,000 Hz. The results in table 12 showed significant correlation between duration of exposure to noise and mean hearing threshold at all frequencies.

Table 12 Correlation coefficient between duration of exposure to noise and mean hearing threshold from 500 to 8,000 Hz of sensorineural hearing loss army workers.

Frequency(Hz)	r	p-value
500	0.176**	0.007
1,000	0.146*	0.024
1,500	0.200**	0.002
2,000	0.234**	0.000
3,000	0.243**	0.000
4,000	0.303**	0.000
6,000	0.139*	0.032
8,000	0.196**	0.002

Number of ears = 238

*Significant at p-value < 0.05 ,** Significant at p-value < 0.01

Table 13 showed the mean and standard deviation of exposure to noise in male and female sensorineural hearing loss army workers. The mean and standard deviation of duration of exposure to noise in male and female sensorineural hearing loss army workers were 20.98 (SD=8.30) and 20.00 (SD=12.39) years, respectively. The t-test showed no significant difference between duration of exposure to noise in male and female sensorineural hearing loss army workers.

Table 13 Mean and Standard deviation of duration of exposure to noise in male and female sensorineural hearing loss army workers.

Male (n =204 ears)		Female (n=34 ears)		t	p-value
Mean	SD	Mean	SD		
20.98	8.30	20.00	12.39	0.444	0.660

Table 14 showed the mean of hearing threshold in each frequency from 500 to 8,000 Hz and distributed by duration of exposure to noise.

Table 14 Mean hearing threshold of army workers who had sensorineural hearing loss distributed by duration of exposure to noise.

Duration of exposure to noise (Year)	Frequency (Hz)							
	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000
1-10 (n=45 ears)	24.11	22.11	21.56	17.56	26.33	33.22	42.44	31.11
11-20 (n=56 ears)	24.55	22.32	23.21	19.73	28.93	36.34	41.43	32.95
21-30 (n=119 ears)	26.34	23.82	25.34	24.03	33.99	41.81	45.50	38.11
31-41 (n=18 ears)	32.78	31.39	33.33	31.39	43.33	52.50	53.06	50.56

Figure 4 showed composite audiogram that was plotted by mean hearing threshold in each frequency from 500 to 8,000 Hz of army workers who had sensorineural hearing loss distributed by duration of exposure to noise. The greatest hearing impairment occurred at 6,000 Hz in all groups.

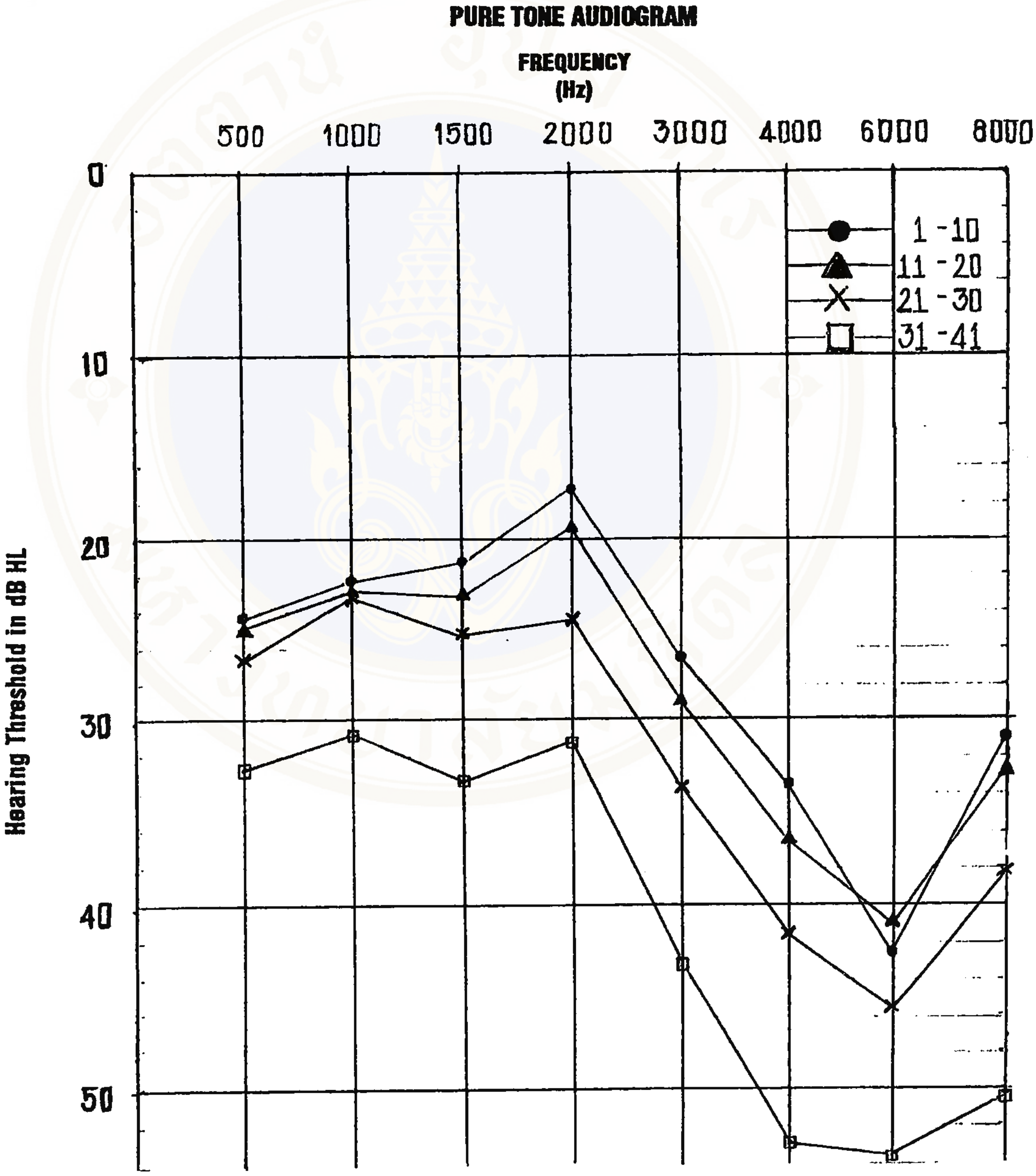


Figure 4 Composite audiogram by mean hearing threshold of sensorineural hearing loss army workers distributed by duration of exposure to noise.

5. The Relationship between Age of Workers and Hearing Threshold

Pearson's correlation coefficient was used to find the relationship between age of workers and mean hearing threshold from 500 to 8,000 Hz. The results in table 15 showed significant correlation between age of workers and mean hearing threshold at all frequencies.

Table 15 Correlation coefficient between age of workers and mean hearing threshold from 500 to 8,000 Hz of sensorineural hearing loss army workers.

Frequency(Hz)	r	p-value
500	0.231**	0.000
1,000	0.168**	0.009
1,500	0.221**	0.001
2,000	0.228**	0.000
3,000	0.290**	0.000
4,000	0.327**	0.000
6,000	0.192**	0.003
8,000	0.199**	0.002

**Significant at p-value < 0.01, Number of ears = 238

Table 16 showed the mean and standard deviation of age in male and female sensorineural hearing loss army workers. The mean and standard deviation of age in male and female sensorineural hearing loss army workers were 40.28(SD=7.10) and 45.65(SD=9.44) years, respectively. The t-test showed no significant difference between age in male and female sensorineural hearing loss army workers.

Table16 Mean and standard deviation of age in male and female sensorineural hearing loss army workers.

Male (n =204 ears)		Female (n=34 ears)		t	p-value
Mean	SD	Mean	SD		
45.28	7.10	45.65	9.44	0.217	0.829

Table 17 showed the mean of hearing threshold in each frequency from 500 to 8,000 Hz and distributed by age groups.

Table 17 Mean hearing threshold of army workers who had sensorineural hearing loss distributed by age groups.

Age (Year)	Frequency (Hz)							
	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000
21-30 (n=9 ears)	23.89	21.83	21.67	18.27	25.87	30.96	39.33	29.81
31-40 (n=52 ears)	24.04	22.86	22.12	19.44	26.67	31.67	43.89	35.00
41-50 (n=124 ears)	25.16	23.89	23.95	21.85	32.42	41.53	44.72	37.02
51-60 (n=53 ears)	30.19	27.55	29.62	28.02	38.21	45.57	49.15	42.17

Figure 5 showed composite audiogram that was plotted by mean hearing threshold in each frequency from 500 to 8,000 Hz of army workers who had sensorineural hearing loss distributed by age groups. The greatest hearing impairment occurred at 6,000 Hz in all groups.

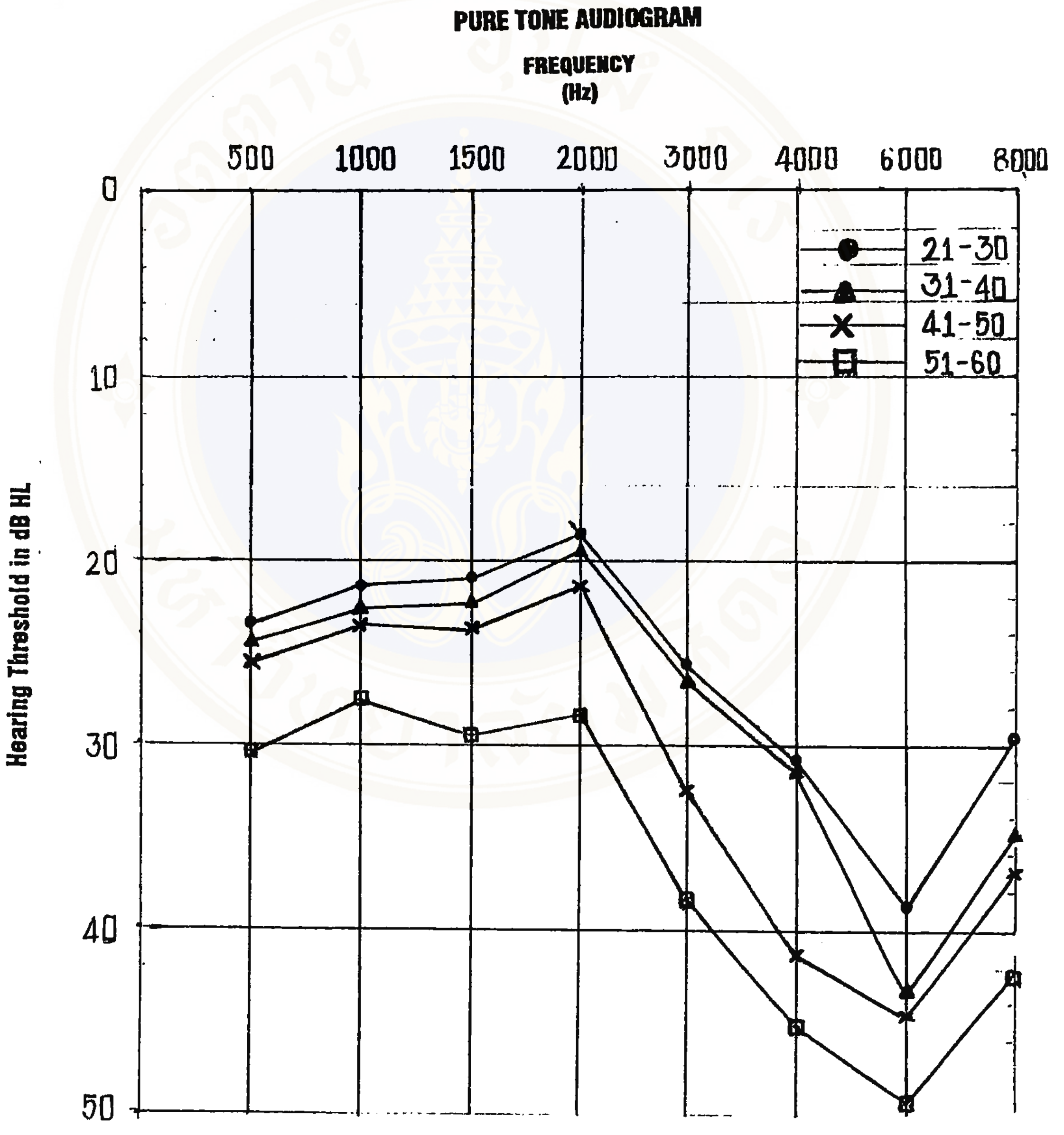


Figure 5 Composite audiogram by mean hearing threshold of sensorineural hearing loss army workers distributed by age groups.

6. The Relationship between Working Area and Hearing Threshold

The one hundred and thirty-one army workers who had sensorineural hearing loss were divided into six areas of working. Table 18 showed the mean of hearing threshold in each area. The results showed the severity of hearing loss occurred at area B, area A, area C, area D, area E and area F respectively.

Table 18 Mean of hearing threshold of sensorineural hearing loss distributed by area of working.

Area (n)	A (67)	B (42)	C (55)	D (15)	E (17)	F (42)
Mean	27.16	27.50	25.36	24.67	24.41	24.05

The t-test showed significant difference between hearing threshold in area A and area F at 3,000 and 4,000 Hz and showed significant difference between hearing threshold in area B and area F at 500 and 1,000 Hz as shown in table 19.

Table 19 Comparison of mean hearing threshold between working area groups distributed by frequencies.

Area		Frequency (Hz)							
		500		1,000		1,500		2,000	
		t	p-value	T	p-value	t	p-value	T	p-value
A	B	0.166	0.868	0.982	0.328	0.913	0.363	0.151	0.880
A	C	1.024	0.308	0.205	0.838	0.639	0.524	0.665	0.507
A	D	0.846	0.398	0.485	0.629	0.182	0.856	0.523	0.603
A	E	0.502	0.617	0.210	0.834	0.043	0.966	0.984	0.328
A	F	1.612	0.110	1.250	0.214	1.132	0.260	1.411	0.161
B	C	1.328	0.187	0.891	0.375	0.364	0.716	0.780	0.437
B	D	1.776	0.081	1.144	0.258	0.781	0.438	0.640	0.525
B	E	0.671	0.505	0.388	0.699	0.597	0.553	1.045	0.300
B	F	2.031*	0.046	2.112*	0.038	1.771	0.080	1.500	0.138
C	D	0.356	0.723	0.773	0.442	0.639	0.525	0.130	0.897
C	E	0.091	0.928	0.079	0.938	0.441	0.660	0.662	0.510
C	F	0.894	0.374	1.659	0.100	1.702	0.092	0.888	0.377
E	D	0.284	0.780	0.467	0.644	0.100	0.921	0.426	0.673
E	F	0.593	0.556	0.755	0.459	0.669	0.506	0.081	0.936
F	D	0.327	0.745	0.433	0.667	0.626	0.534	0.540	0.591

Table 19 (Continued)

Area		Frequency (Hz)							
		3,000		4,000		6,000		8,000	
		t	p-value	T	p-value	t	p-value	T	p-value
A	B	1.307	0.194	1.815	0.061	0.120	0.905	0.341	0.734
A	C	1.703	0.091	1.320	0.189	0.245	0.807	0.449	0.654
A	D	0.942	0.349	1.405	0.164	1.594	0.115	0.963	0.338
A	E	1.932	0.057	1.124	0.264	0.728	0.469	1.129	0.262
A	F	2.693**	0.008	3.102**	0.002	1.717	0.089	0.630	0.530
B	C	0.262	0.792	0.847	0.399	0.100	0.921	0.053	0.958
B	D	0.005	0.996	0.111	0.912	1.478	0.145	1.355	0.183
B	E	0.980	0.331	0.427	0.671	0.611	0.543	1.174	0.245
B	F	1.217	0.227	0.874	0.384	1.478	0.143	0.851	0.397
C	D	0.191	0.849	0.498	0.620	1.549	0.126	1.214	0.229
C	E	0.816	0.417	0.205	0.838	0.602	0.549	1.354	0.180
C	F	0.964	0.337	1.733	0.086	1.534	0.128	1.014	0.313
E	D	0.943	0.353	0.281	0.781	0.749	0.459	0.160	0.874
E	F	0.230	0.819	1.097	0.277	0.465	0.643	0.727	0.470
F	D	1.114	0.270	0.778	0.440	0.502	0.618	0.586	0.561

*Significant at p-value < 0.05, **Significant at p-value <0.01

Number of ears = 238

7. The Relationship between Sex and Hearing Threshold

The mean and standard deviation of hearing threshold in each frequency from 500 to 8000 Hz in male and female sensorineural hearing loss army workers were analyzed as showed in table 20. The t-test showed significant difference between hearing threshold in male and female sensorineural hearing loss army workers at 1500, 2000 and 4000 Hz.

Table 20 Mean and standard deviation of hearing threshold in male and female sensorineural hearing loss army workers.

Frequency (Hz)	Male (n=204)		Female (n=34)		t	p-value
	Mean	SD	Mean	SD		
500	26.18	9.47	24.85	5.84	1.102	0.274
1000	23.95	10.53	22.35	7.10	0.850	0.396
1500	25.15	11.97	22.21	6.30	2.151*	0.034
2000	22.89	13.89	19.12	6.68	2.512*	0.014
3000	32.72	15.73	28.09	8.79	1.672	0.096
4000	40.78	16.80	33.53	10.91	3.283*	0.002
6000	45.10	17.31	40.88	12.21	1.363	0.174
8000	36.86	21.45	34.41	16.87	0.634	0.527

*Significant at p-value < 0.05, Number of ears = 238

CHAPTER V

DISCUSSION

1. Prevalence of Hearing Loss

The purpose of this study was to investigate sensorineural hearing loss among army workers in the small arm ammunition factory, ordnance department. The prevalence of sensorineural hearing loss was 80%, which is very high when compared with the other study. The high prevalence of sensorineural hearing loss may be due to the following factors:

1.High intensity noise was produced in the factory, ranging from 90.4-105.6 dBA.

2. The army workers were fixed to the machine so that they were over-exposed to that high intensity noise level all day long.

3. The factory was sealed in all direction in which the noise can not be let off.

4. Most of the army workers (91.46%)do not used hearing protection.

According to Wisuthipat (12) 's study on the prevalence of sensorineural hearing loss in the automobile factory worker, the prevalence was 65.31%. Dampsey (32) showed the prevalence of sensorineural hearing loss among factory workers was 69.74%. Nakropthai (26) studied prevalence of sensorineural hearing loss in Sriracha Pelletizing company and found that the prevalence was 52.30%

This study agrees with these results in that the prevalence of sensorineural hearing loss was high among factory workers.

Harnchumpol (23) studied the effect of noise on hearing in Thai Military gun shooting advisers and reported the prevalence of 64.35%.

Ylikoski (31) also studied the prevalence of hearing loss of army officers with long-term exposure to gunfire noise. The prevalence was 68%.

These authors also showed a high prevalence of hearing loss among gunfire noise exposed officers.

However, Amartayakul (22), Kasetvetin (24), Pruegsanusak (25), Daungrussami (27), Walen et al. (28), and Klockhoff et al. (30) reported much lower prevalence, which was 4-36.2%. The lower prevalence of hearing loss in Amartayakul' s study (4%) may be due to the strict noise protection measures in those factories.

Kasetvetin (24) and Pruegsanusak (25) studied the prevalence in military students which showed some difference from this research. This study found some differences in these subjects when compared to this study, i.e.

1.Duration of exposed: Subjects in their studies were military cadets. They were exposed to gunfire noise in a short duration.

2.Character of noise exposed: These military cadets were exposed to gunfire noise, which was impulse noise, whereas army workers were exposed to steady-state noise.

The lower prevalence in other studies, i.e. Daungrussami (27), Walen (28), Klockhoff (30) was may be due to good noise protection.

The result of this study showed that one hundred and thirty one army workers who had sensorineural hearing loss were divided into 2 group. The results showed 22.9% of them had sensorineural hearing loss; and 77.1%, registered hearing loss.

Most of registered hearing loss army workers (53.47%) had registered hearing loss type R1 (Bilateral typical noise-induced hearing loss)

The high prevalence of bilateral typical noise-induced hearing loss that may be due to the position of workers which exposed them to noise in both ears.

According to Pruegsanusak (25), Wisuthipat (12) and Kasetvetin (24) s' study on the type of registered hearing loss, Most of the subjects who had registered hearing loss exhibited hearing loss type R2 (Unilateral typical noise-induced hearing loss).

The high prevalence of unilateral typical noise-induced hearing loss may be due to most of subjects being gun shooters who had exposed to noise predominantly in one ear.

2. The Level of Noise in the Small Arm Ammunition Factory

The result of this study found intensity of noise level in the small arm ammunition factory was at average of 90.4 – 105.6 dBA and type of noise was steady-state noise.

The high intensity of noise level in the small arm ammunition factory may be due to the following factors:

1.The machines in the small arm ammunition factory were hard machines in which they produced high intensity of noise.

2.The factory was sealed in all direction in which the noise can not be let off.

3. Frequency of Sensorineural Hearing Loss

In army workers with sensorineural hearing loss, the hearing loss occurred at 3,000-8,000 Hz. The sensorineural hearing loss was greatest at 6,000 Hz. Most of them (48.95%) had hearing loss at 6,000 Hz.

The result from this study was similar to the study of Kasetvetin (24), Daungrussami (27), Dempsey (32), Pelausa et al. (35), and Chun et al. (36).

According to the report by Taylor et al. (34), the hearing loss was greatest at 4,000 Hz and these may be due to the differences in type of noise and intensity of noise.

The army workers with sensorineural hearing loss were divided into unilateral and bilateral hearing loss. Most of the army workers had bilateral hearing loss (81.68%). In the group of unilateral hearing loss, fifty-four point sixteen percent had left ears hearing loss and forty-five point eighty-four percent had right ears hearing loss.

The result from this study was similar to the study by Nakropthai (26) and Helmkamp (57).

The high prevalence of bilateral hearing loss may be due to position of army workers, which exposed them to noise in both ears.

However, the study by Kasetvetin (24), Daungrussami (27), Klockhoff (30), and Charakorn (40) showed high prevalence of unilateral hearing loss. Most subjects were gunfire shooters. They found the use of shoulder weapon caused more hearing loss predominantly in one ear.

The high prevalence of unilateral hearing loss in other studies, i.e. Wisuthipat (12) and Garcia et al. (38) was due to the position of workers.

4. The Relationship between Duration of Exposure to Noise and Hearing Threshold

Pearson's correlation coefficient was used to analyze the correlation between duration of exposure to noise and mean hearing threshold from 500 to 8,000 Hz. The results showed significant correlation between duration of noise exposure and mean hearing threshold at all frequencies, that is, the longer they exposed to noise, the increased the hearing threshold. This may be due to that the longer they exposed to noise, the increasing time for hearing organ destruction.

This finding agreed with the study of Kasetvetin (24), Chavalitskulchai et al. (48), Nakropthai (26), and Staloff et al. (29). They found the duration of noise exposure influenced hearing loss.

5. The Relationship between Age of Workers and Hearing Threshold

Pearson's correlation coefficient was used to analyze the correlation between age of workers and mean hearing threshold in each frequency from 500 to 8,000 Hz. The results showed significant correlation between age of workers and mean hearing threshold at all frequencies, that is, the older the army workers, the increased the hearing threshold. This may be due to that hearing organ degenerated with aging.

This finding agreed with the study of Nakropthai (26), Chavalitskulchai et al. (48), and Rop et al. (51). They found that the hearing loss increased as the age of workers increased.

6. The Relationship between Working Area and Hearing Threshold

The one hundred and thirty one army workers who had sensorineural hearing loss were divided into 6 areas of work, namely zone A, B, C, D, E, and F. The results showed significant difference between hearing threshold in area A and area F at 3,000 and 4,000 Hz and showed significant difference between hearing threshold in area B and area F at 500 and 1,000 Hz.

Noise levels at area A, area B, and area F were 105.6 dBA, 104.3 dBA, and 90.4 dBA, respectively. Difference of noise level at area A and area F, area B and area F were 15.2 dBA and 13.9 dBA, respectively. This huge difference caused significant difference between hearing threshold.

This result agrees with those of Nakropthai.(26)

7. The Relationship between Sex and Hearing Threshold

The relationship between sex and hearing threshold was studied in each frequency from 500 to 8,000 Hz. The result significantly showed that male hearing threshold was poorer than in female at 1,500, 2,000, and 4,000 Hz. This result agrees with those of Nakropthai (26), Szanto et al. (53), and Rop et al. (51).

These may be due to difference of activities between male and female army workers. Males usually have activities that exposed to louder noise than females do, for example, shooting sport, drinking at public house in which there were loud music and loud noise.

CHAPTER VI

CONCLUSION

Conclusion

1.One hundred and sixty four army workers were tested with pure tone audiometry and tympanometry. The results showed 80% of them had sensorineural hearing loss; 5%, conductive hearing loss; and 15%, normal hearing. No mixed hearing loss was observed in this research.

One hundred and thirty one army workers who had sensorineural hearing loss were divided into 2 groups. Most of sensorineural hearing loss army workers had registered hearing loss (hearing loss at high frequencies) (77.1%), and the prevalence of sensorineural hearing loss (hearing loss at all frequencies) was 22.9%.

Most of registered hearing loss army workers had registered hearing loss type R1.

2.The result of this study found intensity of noise in small arm ammunition factory was at average of 90.4-105.6 dBA and type of noise was steady-state noise.

3.In army workers with sensorineural hearing loss, the hearing loss occurred at 3,000-8,000 Hz. The sensorineural hearing loss was greatest at 6,000 Hz. Most of them (49.16%) had hearing loss at 6,000 Hz, 28.57% had hearing loss at 4,000 Hz, 20.59% had hearing loss at 8,000 Hz, and 1.68% had hearing loss at 3,000 Hz. The average hearing threshold of them at 6,000 Hz was poorer than other frequencies.

Most of sensorineural hearing loss army workers had bilateral hearing loss (81.68%), and unilateral hearing loss was 18.32%. For army workers who had unilateral hearing loss, 45.84% exhibited right ear hearing loss, and 54.16% exhibited left ear hearing loss.

4. The present research found significant correlation between duration of exposure to noise and means hearing threshold at all frequencies in sensorineural hearing loss army workers.

5. The present research found significant correlation between age of workers and mean hearing threshold at all frequencies in sensorineural hearing loss army workers.

6. The present research found significant difference between hearing threshold of sensorineural hearing loss army workers in area A and area F at 3,000 and 4,000 Hz and area B and area F at 500 and 1,000 Hz.

7.The results of this research showed significant difference in gender. Male hearing threshold was poorer than those of sensorineural hearing loss female army workers at 1,500, 2,000, and 4,000 Hz.

Recommendation for Further Study

1. Sensorineural hearing loss among the personals that work in other army industrial should be further studied.

2. The relationship between hearing impairment and speech perception should be investigated. Speech audiometry should be included in the further study.

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APPENDIX A

QUESTIONNAIRE

AUDIOLOGICAL RECORD

PART 1 General information: Date record...........................

Name......................................Present age................yr./..................m

PART 2 Medical History & Previous Noise Exposures:

Last 2 types of job before present employment :

1...Department.................................

2...Department.................................

Post head trauma Yes....No.... Post C.N.S. disorders Yes....No....

Hearing loss in family Yes....No.... Use of ototoxic drugs Yes....No....

Trauma of the ear Yes....No.... Otorrhea history Yes....No....

Previous ear surgery Yes....No....

Heart disease Yes....No.... Diabetes Mellitus Yes....No....

Others history of noise exposure.............................Time...........................

Present pre-employment hearing condition Poor.... Fair... Good....

Experience of tinnitus Yes....No....

Experience of vertigo-dizziness Yes....No....

PART 3 Current Noise Exposure at Present Employment :

Date job title......................................Department...............................

Present department...............................

Type of noise exposure Steady.... Impulse.... Mixed stead & Impulse....

Period of working......hours/day.........day/week time pause interval......

Ear protection Was recommended.... Never been recommended....

Type of protection Ear plug.... Ear muff.... Foreign made....

Wearing Always.... Sometime.... Never....

PART 4 Audiologic Analysis:

Ear		500	1000	1500	2000	3000	4000	6000	8000
RT	A.C.								
	B.C.								
LT	A.C.								
	B.C.								

TYMPANOMETRIC

Results...

APPENDIX B

INSTRUMENT and HEARING PROTECTOR

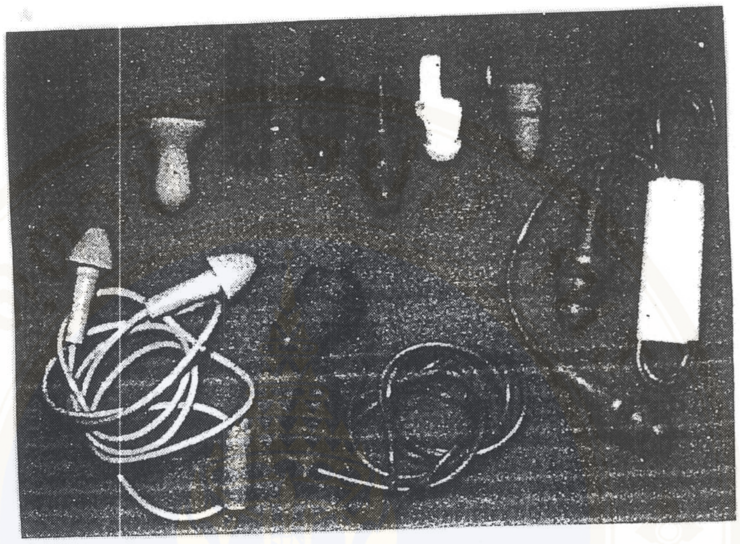

Figure 6 Earplug

Figure 7 Earmuff

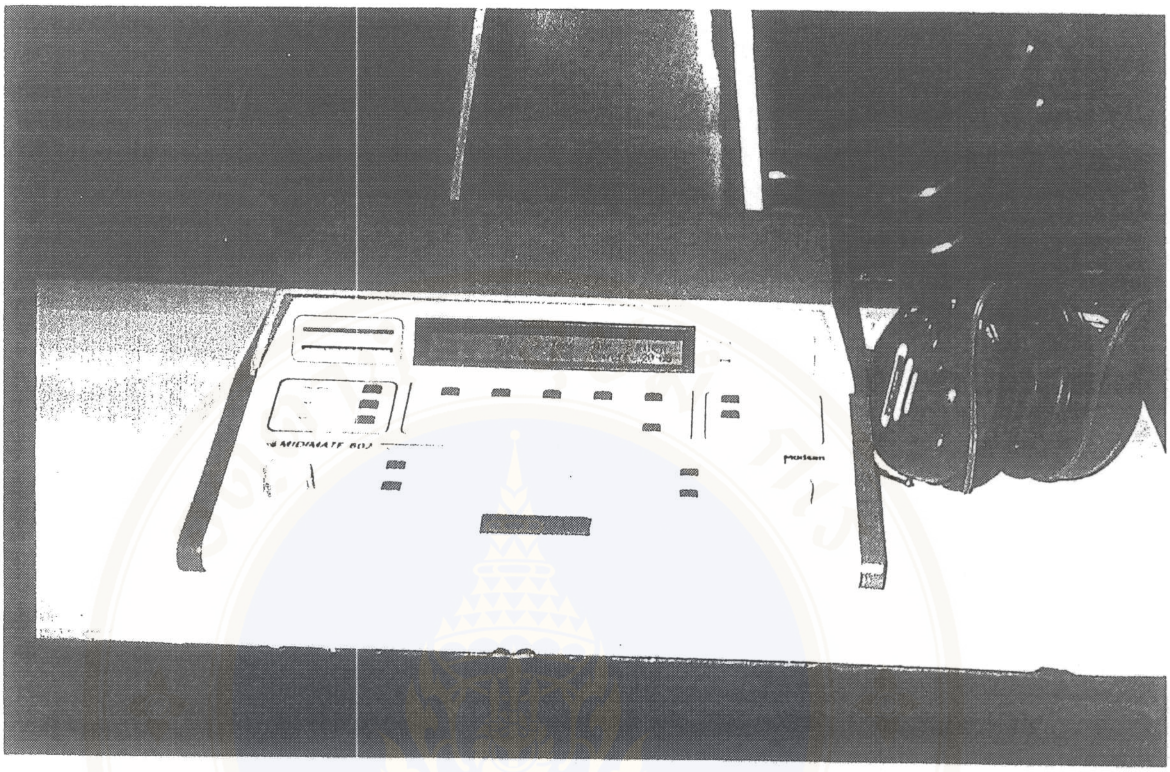

Figure 8 Audiometer

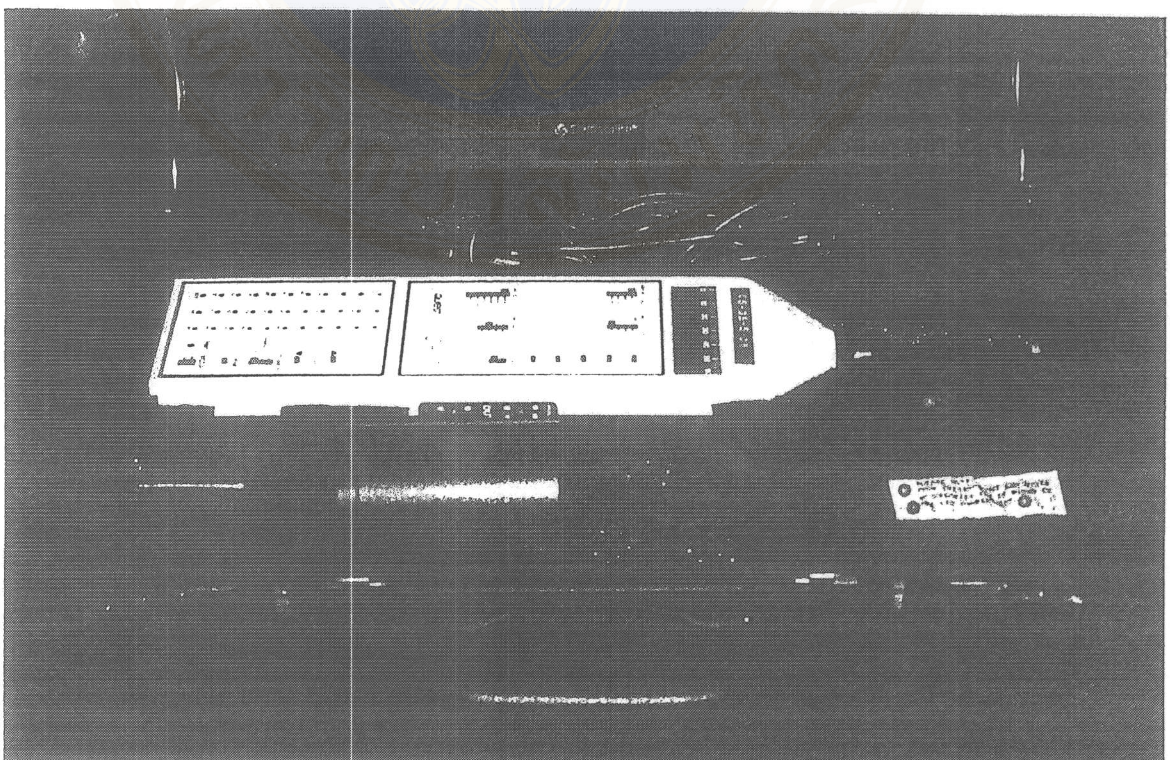

Figure 9 Sound level meter

BIOGRAPHY

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DATE OF BIRTH	July 17, 1971
PLACE OF BIRTH	Nakornratsima, Thailand
INSTITUTE ATTENDED	The Royal Thai Army Nursing Collage, 1991-1995:
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