A REVIEW ON AUDIOLOGICAL EVALUATION OF NIHL

REG. NO. M9702

AN INDEPENDENT PROJECT SUBMITTED AS PART FULFILMENT OF FIRST YEAR M.Sc, (SPEECH AND HEARING) TO THE UNIVERSITY OF MYSORE

ALL INDIA INSTITUTE OF SPEECH AND HEARING
MYSORE - 570 006

MAY 1998

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CERTIFICATE

This is to certify that the Independent project entitled, **A REVIEW OH AUDIOLOGICAL EVALUATION OF NIHL** is a bonafide Work in part fulfillment for the First year M.Sc. in Speech and Hearing of the student with **Reg.No. M9702.**

Director
All India Institute of
Speech and Hearing
Mysore - 06

Mysore
May 1998

CERTIFICATE

This is to certify that the Independent project entitled, **A REVIEW ON AUDI0L06ICAL EVALUATION OF NIHL** has been prepared under my supervision and guidance.

Manjula.P

Guide

Mrs. MANJULA.P.

Lecturer in Audiology

AIISH, Mysore - 06

Mysore

May 1998

DECLARATION

I hereby declare that this **independent project** entitled **A REVIEW ON AUDIOLOGICAL EVALUATION OF NIHL** is the result of my own study under the guidance of Mrs.MANJULA.P, Lecturer in Audioiogy, Department of Audiology, All India Institute of Speech and Hearing, Mysore - 06, has not been submitted earlier to any university for any other Diploma or Degree.

Mysore
May 1998

Reg.No. M9702

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INTRODUCTION

INTRODUCTION

Ear is one of the most complex and intriguing organs in man known to science. Ear is the means by which sound waves are transmitted to the brain and sound is heard. The human ear is sensitive to sound waves vibrating at frequencies as low as 20Hz upto those as high as 20,000Hz. For an individual to hear a sound, it must be loud enough to reach his threshold of hearing for that particular frequency. Our ears are most sensitive in the frequency range between l,000Hz and 3,000Hz i.e., ears require lesser intensity in this frequency region to hear. Tones of very low frequency range activate our sense of touch, since the sound waves stimulate the vibratory sense endings in our skin and therefore we "feel the sound" rather than "hear the sound". As long as the sound is within a certain intensity range, it will be pleasing to the ear. Once this sound causes disturbance or annoyance to an individual, it will be considered as noise.

Loud noise not only causes damage to hearing but it is known to adversely effect people working in the industry causing annoyance, decrease in work efficiency, sleep disturbances, psychological distress, physiologic changes including changes in heart rate, changes in blood pressure, decrease in blood sodium level in blood. The most important effect, is infact a direct result of the primary auditory effect, that is the obvious interferences with speech communication due to the masking effect. Before we go into the details of the effects of noise on hearing, it is necessary to know the structure and the functions of the human ear. Anatomically, the human ear may be divided into three parts-Outer ear, Middle ear and Inner ear. Outer ear consists of the pinna or auricle and the external auditory canal. Middle ear is an air filled cavity, whose boundaries are the tympanic membrane on the lateral side and the oval window into which the footplate of the stapes fits, on the medial side. The ossicular chain of three small bones (malleus, incus, and stapes) and the opening for the eustachian tube are in the middle ear. On the medial side of the oval window is the inner ear, which is embedded in the petrous part of the temporal bone. Inner ear houses the sensory end organ of hearing, the organ of corti. Inner ear also contains three types of fluids - perilymph, endolymph and cortilymph. Inner ear is also called the labyrinth. It consists of bony and membranous labyrinth. The cochlea is coiled from base to apex and has 21/2 turns. The organ of corti which is housed in the inner ear contains between 20,000 and 30,000 minute sensory cells on the basilar membrane from which very fine hairs or cilia extend. On top of these hair cells is the tectorial membrane. The hair cells respond selectively according to the frequencies of the sounds the ear is transmitting.

Sound waves are carried through the air, collected into the ear canal and directed towards the tympanic membrane. As the tympanic membrane vibrates, the vibrations are transmitted through the middle ear by the means of three small bones. The footplate of stapes attached to the oval window moves in and out and this creates an alternate positive and negative pressure in the fluid within the cochlea at a extremely rapid rate. Action of the stapedial footplate causes fluid waves to form in the inner ear. As the fluid waves, put in motion by the stapedial footplate at the oval window of the cochlea, selectively stimulate the haircells on different regions of the basilar membrane, the nerve endings at the base of the hair cells gather together the impulses thus generated into a sort of cable that carries them along the VIII nerve and auditory pathway into the auditory centers of the brain.

Hearing impairment can be defined as a deviation or change for the worse in auditory function, usually outside the range of normal [Newby & Popelka, 1992]. Damage at any stage of hearing can cause hearing loss... There are many causes for hearing loss. One among them is hearing loss due to noise. This is called Noise Induced Hearing Loss (NIHL). NIHL continues to be a significant public health problem. Noise by definition is any undesired 3ound and by extension, noise is any unwanted disturbance within a useful frequency band. Noise, like any other sound, is defined in terms of its duration, frequency spectrum and intensity measured in Sound Pressure Level (SPL) and expressed in decibels (dB).

Noise may be continuous, intermittent, impulsive or explosive. It may be steady state or fluctuant.

The fact that noise can be detrimental to the auditory sensory system has been known for centuries. The effects of noise on hearing may be temporary or permanent. The principle index of the existence of these effects has been measured changes in the hearing sensitivity or threshold hearing levels. These changes are represented by the difference between hearing threshold levels measured before and after a specified exposure to noise or in comparison to normal hearing.

The effects of noise may be studied under:

- Acoustic trauma.
- Temporary threshold shift (TTS)
- Permanent threshold shift (PTS)

Acoustic trauma is the injury to the ear by a single brief exposure to loud sound, such as an explosion or a gun blast. This exposure causes immediate hearing loss accompanied by fullness and ringing in the ear. There may also be a rupture of the eardrum and disruption of ossicular chain. The loss of hearing may be severe at first, but much recovery can be expected. The amount of loss depends on the intensity and duration of the noise and the sensitivity of the ear; The loss may be greater and may involve a broader range of frequencies. It may be unilateral or bilateral. The degree of hearing loss may be more 3oon after the acoustic trauma.

Temporary Threshold Shift (TTS); If the change in hearing sensitivity is reversible and recovers to pre-exposure levels within some time interval following noise exposure, it is called Noise Induced Temporary Threshold Shift (NITTS). The occurrence of TTS and recovery from the temporary change in hearing sensitivity depend on many factors which include the characteristics of the fatiguing noise such as its spectrum, intensity, duration and temporal pattern. Mills (1982) detected TTS when the exposure levels exceeded 74dB at 4 kHz, 78dB at 2kHz and 82dB at 1k & 0.5 kHz. Two assumptions were made.

1. Risk to the inner ear from noise is extremely small beneath these levels.

2. TTS at asymptote produced by a given sound is the upper limit of PTS.

For a given noise, there is an asymptotic point where no further TTS occurs irrespective of the continued exposure to noise. Melnick (1976) reported that in man, for moderate levels of exposure to continuous noise, asymptotic threshold shift (ATS), occurs, after 8-12 hours of noise exposure.

The amount of threshold shift and the frequencies affected depend on the spectrum and level of exposure to noise. A primary factor influencing the development of TTS is the intensity of the noise. The relationship of TTS to sound exposure increases in complexity when the stimulating sound is intermittent or fluctuating as opposed to steady state. The exposure time pattern also influences TTS development and recovery. TTS from intermittent sound is less, than if there had been continuous exposure to same sound.

Permanent Threshold Shift (PTS): If the loss of hearing sensitivity resulting from exposure to hazardous noise persists throughout the lifetime of the affected person, it is called PTS. PTS is an irreversible elevation of the auditory threshold associated with permanent pathological changes in the cochlea. The factors which influence the amount of TTS also are important influences on the development of PTS. Hearing loss resulting from the hazardous effects of noise, especially in the typical industrial noise environment, progress in a fairly well established, recognizable pattern. Hearing loss at 4000Hz is the hallmark of NIHL.

The factors which influence the audiometric pattern of NIHL are - (a) Lack of extreme variation in industrial noise spectra. (b) Transfer characteristics of the mechanical conductive elements of the human auditory system, where the pinna, ear canal and the middle ear structures enhance transmission of sound energy in the 2000 to 4000 Hz range.

Noise induced PTS increases as the level of the off-ending noise increases.

The exact relations of fluctuating, intermittent and impulsive noise to permanent hearing loss have not been firmly established and are the subject of considerable controversy.

Tinnitus is fairly constant concomitant of industrial hearing loss, which is frequently present for some hours after noise exposure but fortunately usually disappears.

It is generally accepted that when noise exposure ceases, the hearing will not worsen and indeed may even improve.

For industrial purposes the Environmental Protection Agency (EPA) recommends a limit at 75dB(A) for continuous exposures of 8 hour with other patterns of exposure restricted to the same total energy (3dB rule). A corresponding limit of 90dB(A) with an increase of 5dB for each halving of duration of exposure was proposed in 1969 by the American conference of Governmental Industrial Hygienists. This is still used by Occupational Safety and Health Administration (OSHA). EPA recommendation is considered by many to be overprotective and the OSHA rule is considered by as many others to be lax (Donald H.Eldredge, 1976).

Audiological evaluation is a necessity for those individuals exposed to noise, be it a single exposure or a long term exposure. Audiological tests tell about the threshold shift occurred and periodic testing will tell whether the loss is a temporary or a permanent one.

Need for the study;

Many studies on noise-induced hearing loss are published in various journals/publications.

The present study aims to collect, within one single volume, the audiological evaluations done for NIHL and their results in the past 33 years.

This information is hoped to be of help to the researchers and future students in the field of audiology.

METHODOLOGY

METHODOLOGY

Aim of the study; To review the various articles on NIHL and see the trend in

1. The subjects selected for the test.
2. Tests most frequently used to detect NIHL- Pure tone audiometry, Speech audiometry, Impedance evaluation, OAE, BERA etc.,
3. Tests that are most effective in detecting NIHL.
4. The audiometric patterns seen in NIHL.

The journal articles dealing with audiological evaluation of NIHL were selected. Articles were collected from various journals. The journals which were reviewed were:

(a) Acta otolaryngology (Acta.Otolaryng.)
(b) Archieves of otolaryngology (Arch.Otolaryng.)
(c) Audiology (Audiol.)
(d) British Journal of Audiology (B.J.A.)
(e) Ear and Hearing (E & H)
(f) Hearing Journal. (Hg.J.)
(g) Hearing Research (Hg.Res.)
(h) Journal of Auditory Research (J.A.R.)
(i) Journal of Acoustical Society of America (J.A.S.A.)
(j) Journal of Speech and Hearing Disorders (J.S.H.D.)
(k) Journal of Speech and Hearing Research (J.S.H.R.)
(1) Scandinavian audiology (Scand. Audiol.)

The information from the articles in the above journals are classified under the following heads and tabulated as:

-> Authors (year)

-> Purpose of the study.

-> Subjects.

-> Noise exposure.

-> Test procedures.

-> Result.

-> Discussion.

-> Remarks.

Some of the terminologies used in the following studies are given in the Appendix A.

REVIEW OF LITERATURE

Authors (year))	Purpose of study	Subjects	Noise exposure	Test procedure	Results	Discussion	Remarks
1	2	3	4	5	6	7	&
Akira, O., Eirotsugu, M., Kotaro, Y., Masayasu, M., (1971)	To determine whether hearing loss is produced by vibration alone and whether vibration will increase hearing loss from noise.	S normal male subjects in the age range 19-20 yrs.	Exposed to steady state noise of 10ldB SPL. Noise and vibration. (l0ldB) (SldB) Vibration of 2, 5 & 10Hz at 100 cm/sec^2; 5, 10 and 28 Hz at S00 cm/sec^2 and 10. 20 Hz at 1000 cm/sec^2	Bekesy audiometry using RION AA34 at lkHz 4kHz.	Temporary threshold shift occured after 28 and 68 min of exposure to the vibration of acce-leration 500 cm/sec^2 and frequency 5Hz. TTS by a steady state noise was increased by simul-taneous vibration.	Strong vibration, with accelerations of 1800 cm/sec^2, produced TTS even al 20 Hz of frequency, at which accelera-tion of 580 cm/sec^2 doesnot cause TTS. Thus vibration alone can produce TTS. The greater tbe severity of vibration, the more intense the degree of TTS. The present study shows that simultaneous exposure to noise & vibration made the TTS more severe than either noise or vibration only.	Duration of exposure is not mentioned. More TTS for simultaneous exposure to noise and vibration may be because, there was a vibratory noise of 81dB along with the noise of l0ldB.
Al-Hua, S., at al., (1991)	To establish the presence or absence of a correlation between NIHL and iron deficiency and to study the signific-ance of this corre-lation.	32 iron deficiency and 32 normal rats of 20-25 days of age.	Group I - 16 iron defici-ency rats. Group III - 16 normal rats. Group II - 16 iron defici-ency rats. Group IV - 16 normal rats.	ABR using madsen ERA-2250 Cochlear acrpholo-gical study.	No PTS was seen in normal rats. The ultrastructural correlates in normal rats are stereocilia dis array and aitoch-ondria swelling in outer hair cells.TTS in iron deficiency rats were larger	NIHL, except at very high sound levels, results from insuf-ficient adjustments of the inner ear netabolism to changes of func-tional demands. Therefore changes of the cochlear	The amount of improve-ment and the FTS level is not given.

1	2	3	4	5	6	7	8
			Group I & III exposed to steady state white noise at 110dB SPL for 30 min.		than those in normal rats. The ultrastructural correlates of NIHL in iros deficency rats are pathology of the stereocilia and a significant reduction of nitochondria as sell as slight degeneration of nucleus in the outer hair cells. Iron deficiency can provide a pathological basis for NIHL.	Metabolism induced by iron deficiency tay be accountable for an interaction between NIHL and iron deficiency.	
Illu.L, likrt, C.B. (1!!!)	To examine the relationship between TTS, PTS and cochlear pathology resulting from exposure to three intensities of noise in a species not previously utilized for research is noise induced hearing loss.	ISnormal adult mongolian gerbils divided into 3 groups.	3 groups of six Mongolian gerbils each exposed to two octave(1414-5656Hz) band noise for one hour at 190,110 and 120dB SPL.	Behavioural testing was done to assess the auditory thresholds at 10 frequencies from 0.1 to 16 *KHz.* Thresholds measured at intervals of 0.5, 3,6 and 24hr after exposure, and daily till 28 days. Final testing was done two months after exposure.	Extensive threshold shift was observed is all groups 0.5hr after exposure. Recovery of thresholds from 1-28 days after exposure was approximately exponential. PTS was seen is the 110 & 120 dB SPL groups. With TSo.shrs of SOdB or less, no PTS resulted. iith TSo.shrs above 50 to 60 dB eventual PTS increased linearly with slope of about 1.25 PTS/ TSo.shrs. Relationship between auditory thresholds and cochlear histology-) The hair cell. loss in each of the threegroups well	Behaviour of threshold shift during the initial hours following exposure was related to extent of eventual recovery. Increases in threshold shift after the termination of exposure, except for very low frequencies were always indicative of eventual PTS. Results indicate that apex may react wore slowly to noise exposure than other cochlear regions. Recovery pattern suggests that recovery of function in reversibly dama-	Total duration of exposure is not mentioned.

1	2	3	4	5	6	7	8
					correlated with the behaviourally determined threshold shifts. Variability in PTS and cochlear damage was higher in the 110 dB SPL exposure group.	ged otter hair cells follow a different time course than that seen in similarly damaged inner haircells.	
Annette, K Pappard., Sean, B.P. (1992)	To get an idea of the incidence of NIHL in a proteen & young teen population, & to propose an effective hearing conservation program for a pbysicians practice, audiologists clinic & educational setting.	4121 normals in 1-16 years age range.	Exposed to hunting * Handguns * Rifles Go-Karts, firecrackers, lawn lovers & boom boxes.	Audiometry using Madsen screening audiometers calibrated to ANSI 1969 standards. 500Hz Screened at 25dB. 1 KHz, 2KHz & 4KHz screened at 20 dB.	29 students had NIHL. 12/29 had unilateral loss- 17/29 had bilateral loss. Unilateral loss tend to be more severe than the binnaural losses ranged from 20 dB to 55dB with a mediam of 40 dB at 4kHz. Bilateral loss ranged from from 15 dB to SO dB.	Mostgomery & Fujikawa (1992) suggested that the incidence of hearing loss among 8th graders has increased 4 times in last 10 years. NIHL in children is not only increasing but is also affecting younger population.	Duraticm and level of noise exposure is not mentioned. Unilateral loss - was it left ear or right ear loss? was it related to hand -held weapons?
Axelsson, A., Jerson, T. Lindberg, T., Lindgren, F., (1981)	To evaluate hearing in pupils attending vocational classes which will result in noisy professions.	538 boys in the age range 17-20 yrs and average age of 18.4 yrs and SD of 1.2.	Not specified	Pure tone audioietry using madsen OB -71 audiometer. Frequencies tested- 250, 500, 1k, 2k, 3k 4k, 6k and 8kHz. Audiometer «as calibrated according to ISO389. Audiometric investigation was completed within a 3 months period after the start of the shcool year.	455 boys had normal hearing. 83 boys had hearing loss of lore than 20 dBHL. Out of 83 boys, 36 boys had dip in the audiogram i.e. one frequency worse than all other frequencies. Lef ear was found to be worse than right ear.	Host of the school boys in the present investigation had norial hearing. The 151 incidence of hearing loss in these boys aged 17-20 yrs, lust be considered as quite high. The left ear is statistically poorer than the right at lost frequencies. Audioietric investigation was completed within a 3	The type of noise which the pupils are exposed to and the type of vocational training they were undergoing have not been mentioned.

1	2	3	4	5	6	7	8
						month period after the start of the school year.	
Axelsson, A., Lindgren, F., (197!)	to examine the hearing in **pop** ausicians.	83 Subjects in the age range 17-40 yrs and average age of 26.5 yrs.	Average exposure time for the musicians was 9.3 yrs. They performed 18.3 hrs a week.	Pure tone audiometry using Madsen TDH-80, Madsen OB-70 and Kamplez.	Group mean hearing thresholds shot only a slight deviation from normal. In individual analysis 13-30 were found to have a sensori neural hearing loss. Subjects with hearing loss show a discrete impairement in the frequency range 3-8 kHz.	Only few investigations have reported on the individual hearing in those obviously lost exposed to pop ausic. those studies that have been done have deaonstrated a low incidence of SIHL.	The frequencies tested are not lentioned.
Bergstrom, B., Nystrom, B,, (1986)	To assess the development of hearing loss in individuals during long ten exposure to occupational noise	319 subjects in the age range 17-45yrs and mean age of 33 yrs.	Chemical division - 85dB (A) Saw Mill division - 99dB (A) Working station - 95dB (A) Paper Mil1-94 dB(A) Beater room -100 dB(l)	Pure tone audiometry using Audiovox & a Tegner PTA -9. Frequencies tested were 0.5 1, 2 & 4kHz.	Mean hearing levels deteriorated slowly, especially at 4kHz. No dramatic changes from one year to another were seen. A large proportion of eaployees in the chemical division suffered a bearing loss corresponding to lO disablement.	the results permit us to state that, when lean exposure levels do not exceed 100dB(A) & there it very little impulse noise, the deterioration of hearing above 20dB is so slow that,in industrial audioietry, annual hearing tests will not give significant results.	A large protion of workers in cheiical division with hearing loss could be due to interaction effects of the noise and the chemicals. the chemical to which they were exposed is not mentioned.
Blakesiee E.A., Hpnson, I., Hameraik, E.F. Henderson, D., (1971)	To examine the effects of long-ten exposure to reverberant noise impulses on the	5 monoaural adult chinchillas.	Exposed to repetitive reverberant, impulse noise for ten days produced by a aechanized	Auditory thresholds measured by psychophysical method at frequencies 0.5, 1, 1.4, 2, 2.& 4, 8	threshold shift at 8kHz reached an asymptotic level within one hour from the start of exposure	Exposure to repetitive impulse noise for ten days did lead to an ATS state. The impulse	

1	2	3	4	5	6	7	8
	chinchilla ear.		bauer hitting a steel plate at a rate of 1/sec with a peak pressure of 113dB SPL.	and 16 kHz.	Threshold shift at 0.5kHz leveled-off after 24 hours of exposure. Asyiptotic threshold shift(ATS) levels for both frequencies varied between 30 & 50dB across anmials. Maxi-mum FTS was at 2 and 2.8kHz with Median PTS of 17 i 13 dB respectively.	noise ATS, is attai-ned faster and with a greater degree of variability than comparable levels of ATS induced by continuous noise. nevertheless, the stability of the ATS produced by impulse noise & the consistency across the five animals suggest that the phenomenon say be useful in the sys-tematic study of both TTS i IIPTS.	The total number of exposure perday has not been mentioned. The time duration between the cessation of exposure and the testing is not mentioned. The time gap between the two exposures is not given.
Borg, E., Hilsson, B., Engstrom, B., (1913)	To ascertain the FTS and inner ear patho-logy after exposure to industrial noise in rabbits with unilaterally inacti-vated middle ear muscles.	7 nornal adult rabbits.	Tape with industri-al noise such as impulse noise from sledges & haoners & high sound levels from pneumatic s hand tools (strik-ing nut tighteners. Exposed to 15 tin. 3 different expo-sure levels used were 120,125 & 130dB (A)	Seflexometory . Auditor; brainstei response audiometry.	With normal middle ear reflex very little PTS was found Ihen the inscles were inactivated dar-ing the noisa expo-sure the PTS was very extensivt and covered the mid-fri-guency range.	The results show that the HE miscle reflex signi-ficantly decreases PTS in rabbits expo-sed to high level of industrial noise. PTS after noise in rabbits with inac-tivated ME luscles is similar to the TTS observed in human subjects with Bells Palsy expo-sed to the same noise (Zakrisson et.al., 1980)	

1	2	3	4	5	6	7	8
Botte, M.C., Moaikhein, S., (1994)	To describe the short term affects of tons exposure by aeasuring the effects of exposure duration on the growth of ITS and TLS at different test levels for a •oderate exposure (TLS: Temporary Loudness Shift)	12 normal adults	Sight ear exposed to lOOOHz tone at 65dB SFL for 5 periods of 5 min i.e. a total of 25 min.	Bekesy tracking procedure (pre exposure)was used- Test tones at 30, 40, SO or 60dBSPL were used. 10 successive TTSs were obtained 10 sucessive TLSs recorded. TTS and TLS measureaents were carried-out at the same frequency during 30sec test periods that followed each exposure period.	TTSdata:Mean pre-•xposure threshold was 10.1 dBSPL. Greatest TTS occurred after S ain of exposure & saallest after 15 min. TLS data: TLS were larger than TTS with mean maxima about lldb during the first 15se post-exposure. TLS recovery was rapid with a aean rate of almost 7dB over 15sec. TLS did not vary significantiy for test levels of 30-50dB.	The present data are in agreement with previous studies on short tera TTS (Hirsh & Bilger .1955; Bell *k* Fair. banks 1963;Selters 1964).Part of present data are comparable with those obtained by HcPherson *k* inderson (1971) in siailar conditions. They consider that loudness shift from "50dB exposure is apprently not related to sensitivity changes in the ear". This study concludes that even a low level exposure does reduce loudness.	The procedure used a limited number of levels of comparison tones, the lowest being were only 12dB below the test level.
Botte, H.C., Monikheia., (1994)	To describe the short tera effects of tone exposure by Measuring, the effect of test level on the frequency pattern of TTS 4 TLS for aoderate exposures to tones of different frequencies.	10 norial adult	Exposed to a tone of 500,1kHz or 3kHz at 65dBSPL for a continuous period of Tain.	TTS measurement:pre *k* post-exposure thresholds for 9 test frequencies was obtained. TLS measurement: To equalize the loudness the subjects used the knob of the potentiometer. TTS & TLS for a given test level were measured successively with 9 test frequencies	Naxiaua TTS 7 TLS was observed at exposure frequency & decreased aore or less systematically at lower *k* higher frequencies. TTS i TLS patterns were similar but those of TLS were higher (aore extended than those of TTS. Maximum TTS was lower than maximum TLS.	This experiment conferas that a aoderate exposure results in greater TLS than TTS at the exposure frequency. The TLS results agree with the data of Charroa i Botte (1918) who established frequency patterns of TLS at S5 dB test level after 24s exposure to 500, 1000 i 3000 Hz tones at 75 dB.	The test frequencies are not mentioned. The time duration between the sessation of tone exposure and the test procedure is not gives.

1	2.	3	4	5	6	7-	8
Botte, H.C., Monikheis, S., (1994)	To describe the short ten effects of tone exposure patterby measuring, the early frequency level exposure.	4 adults	light ear exposed to a lOOOHz, 90dB tone for 15 sin.	TTS t TLS for tOphon test tones were measured at seven different frequencies.	TTS data: TTS was greatest above the test frequency. TTS of about 4dB was seen at the exposure frequency 30s after exposure. Maximum TTS (17.8dB) oceared at 150s post-exposure 0.6 octave above the exposure frequency. The whole pattern of TTS diminished 330s after exposure. TLS data: TLS «as maximal (S.2-8.2dB) al 30s after exposure, recovered rapidly (about 4 dB) and was no longer significant 330s after exposure. TLS were approximately constant through the whole range of test frequencies.	This experiment demonstrates short term TTS & TLS also occur after high level exposures. The short ten effects of any exposure affect post-exposure loudness.	
Charles, I.B., James, B.P., Ben, T.M., Robert, T.C., (1978)	To study the effects of noise, dominated by low frequency energy, on hearing.	1 tale chinchillas in 11-32 months age range.	4 animals were exposed to three successive levels of an octave band of noise centered at 63Bz at lOOdBSPL, 110 dBSPL, 120dB SFL. The other 4 animals «ere exposed to three successive levels of an octave band of noise centered at	Behavioural testing at frequencies 0.063, 0.09,0.125,0.5,1,1.4, 2.0 and 4kHz ns carried out-	Little threshold shift(TS) resulted from the lower two exposure levels of 63 Hz noise band. At UOdB exposure level, maximum TS of 43dB occured at 2kHz. PTS of 16dB at 2kHz and 11 dB at 140Hz were found. Exposure to the three levels of lkHz noise band pro-	The most Interesting finding was the high frequency hearing loss produced by the low frequency noise and that noise bands matched within ldB A were not equally hazardous as indicated by damage risk criteria.	frequencies above 4KHz should also have been tested. The level of noise exposure at both frequencies should have been kept same for

1	2	3	4	5	6	7	8
			8SdBSPL, 95dBSPL, Total exposure duration las 72 hours.		and 61dB at 1400Hz. The 95dB exposure level resulted in PTS of 6dB at 1400 Hz and)dB at 2kHz. 63Hz noise band produced nearly twice as much PTS as the l000Hz noise band.		purpose.
Charles, V., (1977)	To determine the adequacy of the auditory evoked response (AER) in the assessment of a asyaptotic RITTS and to investigate the relationship between chinchilla pre-exposure AER threshold and AEE threshold while in a state of asyaptotic IITTS.	8 chinchillas weighing 300-600ga less than 3yrs of age.	Exposed to continuous octave band noise of 4kHz at 8OdB SPL for 96 hrs.	Auditory evoked response threshold test Frequencies tested- l, 2, 4 and 8KHz	Asymptotic threshold shift produced by the noise increased with frequency to 8kHz with a negligible effect at IkBz and progressively higher thresholds at 2, 4 and 8kHz. There is a inverse relationship between pre-exposure threshold and threshold shift in the case of asymptotic IITTS. This relationship is not evident in the case of short term exposures to either steady state or impulse noise.	AEB method is as adequate measure of asymptotic IITTS. Thresholds during long-term noise exposure was found to be determined by the spectral and intensity components of the noise, independent of pre-exposure thresholds.	
Chung, D.T., Smith, F., (1980)	To investigate systematically the pbenoaenon of Tf by Brief Tone Audioaetry of noraal hearing and hearing impaired(NIHL) subjects in both	20 normal subjects in the age range 21-33 yrs and lean age of 2S.6 yrs. 20 subjects with NIHL in the	lot specified J	Bekesy tracking procedure . Audiometer used -> Grason -Stadler 1701- Frequencies tested were 500Hz *i* 4000Hz White noise - 9Sdb SPL.	subjects with ML showed less TI than normals. Frequency effect was found in both groups.	The most notable finding was that the cochlear impaired auditory system has a lessened ability to integrate acoustic energy over longer durations.	Tie age range of the two groups should have been the same for comparison Noise

1	2	3	4	5	6	7	8
	quiet 4 masked conditions for low & high frequencies. TI * Temporal Integration.	age range of 59.8 yrs.		listed under 4 quiet and 4 Miked conditions.		Data here show that in the 4kHz region the difference between the amounts of TI of the two groups is less is the masked condition.	exposure duration & level of noise has not been mentioned. Supra threshold measurement of TI with the masking technique deserves further study.
Chung, D.T., (1982)	1. To study the frequency dependence of temporal integration (TI) is each individual. 2, To determine whether TI should be used in the clinical situation for diagnostic purposes.	14 normal subjects in the age range 20-40yrs. 23 subjects with II1L in the age range 44-72	Not specified	Fixed-frequency Bekesy tracking procedure using Grason-Stadler 1701 audioaeter. Frequencies tested 0.5, 1, 2, 3, 4 and 6kHz.	TI function is tore closely related to the configuration of the audiograi than the hearing threshold level when data of an individual are concerned. TI function is affected by the presence of "Subclinical" cochlear lesions.	The data from individual subjects display that TI is inversely related to cochlear hearing loss i.e. the shape of the TI function resembles the configuration of the corresponding audiograi. The correlation is not sufficient to allow prediction of TI by the degree of hearing loss or vice versa. The results of this study needs to be further substantiated.	

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Cianfrone, 6., Ingrossos, A., Altissimi,, Ralli, 6., Turcheta, R., (1998)	To contribute to the knowledge of noise effects on DPOAE's in the anesthetized guinea Pigs.	5 anesthetized guinea pigs - weighing 90- one an150gms and 380 gms for imal.	Exposed to 110dB SPL pure tones for 45 minutes and the fatiguing tone centered on the geometric lean (GM) of priiaries or 2/3 of GM. One animal was given a second exposure after complete recovery from the first.	DPOAE The relationship between the frequency of the priiaries and the frequency of the exposure tones giving the lain effect. The time course of the amplitude recovery. Pemnent or long-lasting after exposure DP unifications, induced by post recovery repetition of stressing exposure.	The frequency distribution of fatiguing effects on the DP-audiogicalshowed a rewritable fine tuning and a pattern like a LPF. After four hours, in one aniial, there was an enhancement of DP amplitude, coupared to the pre-exposure level. In another aniial, a second acoustic overstimulation produced a lore extensive and tiie lasting effects than the first exposure. (LPF: Low Pass Filter)	The data confins the necessity of monitoring always the time course of drug effects on the otoacoustic emissions before fatiguing measarements in animals. In order to obtain DP, measurable modifications induced by a stressing tone centered on GM, it is necessary to mofify some experimental conditions, like exposure level and duration, level of priiaries, etc. (Martin, et al., 1987).	Frequencies tested are not mentioned.
Clark, W.W, Bohne, B.A., (1987)	To evaluate behavioural measures of hearing loss and cochlear histopathological changes produced by exposure to low frequency noise on interrupted schedules for durations longer than 9 days. To compare the effects on hearing and cochlear damage of exposure on two schedules that had similar duty cycles but different periods.	7 chinchillas of 1 year old at the start of the experiient. 3 in group-1 i 4 in group-2-	Exposed to octave band noise centered at 0.5 kHz of 95 dBSPL. Group-1 were exposed for 6 hours per day for 36 days. Group-2 were exposed for 15 min/hour for 144 days. »	Bearing sensitivity was aeasured behaviourally at 1/4 actave frequency intervals from 0.125 to 16 KHz, before, during and after a period of 1-2 souths of the exposure.	Both groups produced an initial shift of thresholds of 35-45dB After a few days of exposure, thresholds recovered to within 10-15dB of original baseline values eventhough the exposure continued. Measures of recovery lade after completion of the exposures indicated Minimal in all animals. Behavioural and anatomical data indicated that intermitt-	Threshold shifts produced by noise on some interrupted schedules do not produce ATS. Under some schedules of intermittent exposures, the ear can recover as much as 30dB of sensitivity, eventhough the exposure continues. Secondary losses of sensitivity for high frequency signals are sometimes seen. Exposure to an OBI centered at 1.5 kHz	

1	2	3	4	5	6	7	8
					ent exposures prod-uced less TTS and PTS and less cochlear damage than contin-uous exposure of equal energy.	95dB SPL, 6 hr/day for 36 days or 15 •in/hr for 144 days, produces less hearing loss and cochlear damage than continuous exposures.	
Claudia, D.V., filial, L.E., (1998)	To compire the hearing thresholds of a group of 60 recreational shooters of varying ages, with no industrial noise exposure, to the thresholds of an age latched population of individuals with no comparable noise exposure.	60 normals (8 feaale and 52 male) in 11-86 yrs age range.	Began shooting at 16 fears of age.	Audioaetry using Hadseo OB822 - Frequencies tested were 250, 500, 750 1000, 1500, 2000, 3000, 4000, 6000 & 8000 Hz. ford discriuination score. Tympanometry using Maico MA 620 Tyipano-»eter.	Hearing thresholds at all frequencies me torse for the recrea-tional shooters (11-86 yrs) than for a typical age lethod saiple. Significant differe-nces in degree of hearing for shooters Vs their typical age latched saiple «ere at 4 & 6 kHz. Youngest group of shooters had «orse hearing at 2, 3, 4 & 6 kHz. word discrimi-nation score was 81.9% in quiet and 74.4% in noise for shooters. With incre-ase in age, the word discriaination abili-ty decreased both in quiet and in noise. Tympanonetry shoved normal findings.	The recreational shooters ts t group experienced a signi-ficant hearing loss when compared to an age-latched popula-tion. The greatest degree of hearing loss appears to occur at 4000Hz and 6000 Hz. Results also suggest that the hearing loss incurred froa exposure to gunfire noise and froi in-creasing age appears to adversely affect word discriiination ability.	Duration of noise exposure per day is not mentioned. The age at which they began shooting ns 16 yrs. The cause for loss of hearing in subjects between the age range 11-16 yrs is not given.
Cooper, J.C., Owen, H.J., (1976)	To derive an audio-logic profile of HIHL from a single sasple of patients.	225 subjects Kith hearing loss in the age range 21-59 yrs and a	Hot netnioned.	Manual *k* Bekesy audiometers used. Tests performed PTA SET	Tonal thresholds increased systematica-lly from approximately 7 dB at 250Bz to 22dB at 8kHz.	Audiologic profile generated froi the data vas not unex-pected. The attempt to abs-	frequencies tested are not mentioned. TDT t SISI

1	2	3	4	5	6	7	8
		Mean age of 42 years		SDS IDT at 4 kHz SISI at 4 kHz Bekesy tracings.	Speech audioietry produced standard deviations of 7dB for SIT and 30\ for discrimination. Width of continuous Bekesy tracings was narrower than that for the interrupted tracings in 56.5% of the cases.	tract the quantitative stateient of the clinically discernible audiometric notch vas successful. The degree of success suggests tvo applications. First, the failure to obtain an audiometric configuration consistant with a variation of the quartic would seei to suggest causative factor other than noise. The second application is possible within the context of automated hearing conservation programs.	should have been done at other frequencies also, i.e., at 1kHz and 2kHz.
Dancer, &., Grateau,P., Cabanis.A., ?aillant,T., Lafont,!)., (1991)	To investigate thoroughly in tan the existence of delayed TTS following the exposure to actual weapon noises.	28 nale subjects with average age of 20.& years. ^	Group 1 (N = 12) fired 10 rifle shots daily duringF 2 days. Group 2(N=8) fired a burst of 10 shots daily during 2 days. Group 3(N=8) exposed in the free field to 100 rifle shots daily durlng the 2 days.	Field study: Bekesy Audioietry. Frequencies tested- 0.25, 0.5, 1, 2, 3, 4 5, 6, 7 & 8 kHz (Pre-exposure). Post-exposure: Bekesy audioaetry during first, second days of exposure.	A significant nuiber of subjects shoved a •delayed TTS" and/or "rebound recovery" The maximumTTS vas observed at 1 hour after exposure, but the observation of a delayed recovery and a rebound recovery indicate that audiomstric tests should be perfoned in all cases at least upto 4 hours after the exposure.	Measurement of TTS 2min is not sufficient to evaluate the auditory hazards i could lead to an underestiiation of these hazards. To assess the actual risk I to build DEC for impulse noises, audioietric leasurements should be perforaed at different times after the exposure.	Pre & Post-exposure thresholds are not gives. More detailed work ia necessary to determine the corrective factors to apply to the present damage risk

1	2	3	4	5	6	7	8
							criteria.
Daniel, L, Johnson., Carol, E., (1982).	To deteraine the effects of non-occupational noise exposure from guns on the hearing of an occupational noise exposed population.	68 subjects (52 tale & 16 females) in the range 24-64 years & Mean age of 43 years.	Not Specified	Pure tone audioaetry. Frequencies tested- 0.5, 1, 2, 3, 4 4 6kHz "'"	Mean hearing levels between the sale participants exposed to pnfire and those not eiposed,varied between 9 4 16 dB for 3k, 4k & 6kHz. No significant differences in hearing threshold levels of feiale subjects.	The differences in lean hearing levels between noise exposed & unexposed subjects are dearl] visible for the males at 3k, 4K & (kHz. lo significant differences are shown for feiales. This may be partially explained by the types of gun used.	Duration 4 level of exposure, distance between the source 4 the •ar should have been mentioned. Pre-exposure audiograms should have been taken to study the causal effect.
David, Y.C., Glens, N,W., Patrick, G.R., (1983)	To gain insight into the causes of assyametry in cases with confirmed IIBL.	1461 subjects with HIHL in the age range 36-82 yrs.	Shooting	Audiometry at 0.25, 0.5, 1, 2, 3, 4, 6 & 1 Hz. Ipsilateral and contralateral reflex for 1 4 2 KB: tone stimuli.	57 of the claimants had worse hearing in the left ear at 2kHz. 69 of the claimants had a well-defined pattern of hearing loss in which only 2kHz in asyuetrical by 20 dB or lore. Of 69 cases,82.6* had worse hearing thresholds in the left ear at 2KHz. In 50* of the 69 cases, the asyuetry could not be accounted for even after the exaaination of their medical, occupational 4 non-occupational histories Ho difference between	The medical histories of 69 casts were examined 4 no reason for the asyuetry was found in any of the cases.The asyuetry at 2kHz represents a lateral difference in susceptibility to noise damage. This lateral difference teried the "ear effect increases with frequency 4 reaches a peak at the 3-6 KHz area. The average difference in peak is about 3dB.	More supporting evidence and direct systematic studies are required to give a definitve conclusion on the problem. Details on noise eiposure and style of shooting is not given.

1	2	3	4	5	6	78
					the reflex threshold of the right i left ear, both contra and ipsilaterally.	
David, f,C, John, L.F., (1983)	To determine the pre-valence of hearing loss aaong Aray engineers.	209 subjects in the age range 18-50 years. Note: BOS 12 - N=48 HOS 51 - N=22 HOS 62 - N=73 HOS 63 - N=33 MOS 64 - N=24 HOS 76 - N= 9	Basic Engineer(I=4!) 1-15 yrs of service, 86-148dBA, 3-4 hrs daily (MOS-12). Carpenters, Pluibers electricians (H=22), 2-24 years service, 86-127 dBA, 4-6 hrs daily (HOS51). Mechanic (N=73), 1-21 yrs service, 86-118dBA, 5-7 hrs daily (MOS62). Maintenance (1=33), 1-21 yrs Service, 86-112dBA, 6-7 hrs (HQS63).Truckdriver (N-24), 7-23 yrs service, 88-108dBA, 6 1/2 -7 hrs (MOS64). 1-21 yrs service (HOS 76)/M=i).	Fore tone audiometry (meeting ANSI specif-ication). Frequencies 0.5, 1, 2, 3, 4 1 6 kc/s.	Basic engineers -) There is a steady decrease is hearing over time, with the greatest slope in the audiograi froi 2-6kc/it MOSS1 - Showed slightly higher losses at 2 + kc/s than M0S1. personnel. MOS62 - Hearing losseiI lere about !5dB at 2 kc/s and decreased sharply to 45+dB at 6kc/s. MOS63, 64, 76 - The average HTL's closely approximated those foi HOS62.	The poorer hearing of older engineers may indicate that age and noise expo-sure interact to produce more damage with age. The subjects reported no obvious ear or hearing pro-bleis and did not participate in non-military noise-hazardous hobbies or activities.
David, 8.C., Michael, L.I., (1982)	To deteraine the contributions that eye color inforiation aakes in predicting hearing loss. To propose a foriula that best predicts a subjects hearing loss when certain indepen-dent variables, including eye colour, are known	130 norsals (116 tales and 14 females) in 20-65 years age range.	Leq (8) readings in the noisiest depart-»ent were 92dBA; the quietest departient had leq (8) of 78dBA	Pure tone audiosetric thresholds deterrined from 500 through 4000Bz and 3 and 6 *lit.* Subjects eye colour was determined by self report on a question-naire designed for this purpose.	Analysis of variance revealed lean thres-hold differences at 4 i *i* kHz. However, no signifi-cant team threshold differences between eye colour groups were seen when aean thresholds were adjusted for years of exposure in a covariance design.	There is no signifi-cant difference in mean hearing thresh-olds forsubjects in the 3 eye colour groups. Although there is a relationship between eye colour & suscep-tibility to NIHL, these correlations are very modest.

1	2	3	4	5	6	7	8
					y^{l}"A+B_1 X_1 = B_2 X_2 .... lklk y^{la}Predicted average hearing loss. A=Constant. B= Partial regression co-efficiest. X= Values of independent variable.		
Dennis, 6.D., (1976)	To detenine what effect changes in temperature would have on the time course of cochlear Microphonica (CH) during and after exposure to steady noise.	Normal adult chinchillas weighing 425-515 g.	Anaesthetized chinchillas exposed to steady octave band noise with center frequency of 1kHz at 90dB SFL.	CM Measured in response to short tone burst at 0.2 kHz.	Changes in body teiperature and cochlear temperature from 29-39*C had little effect on normal CM.On noise exposure, CM decreased and approached an asyiptote at a rate dependent on the teiperature. Sate of reduction was less at low temperatures than at high temperature, with termination of noise, an initial rapid recovery preceeded a slow recovery toward normal CH values. Slow recovery was inhibited at low tesperatures.	Studies indicate that noise induced reduction of CM lay be linked to proceses of energy metabolism and/or lay involve teiperature dependent structural changes that do not affect normal cochlear responses.	Duration of noise exposure is not given.
Dimon, Marion,i.C Edward,,H,B., (1976)	To detemiae the effect on the auditory threshold of the wrost "neighbourhood"expsure to aircraft	5 young normal subjects.	Exposed to landings or take-offs for six hours which produced a peak level at 11ldBA at the rate of 1 per 1.5	Auditory thresholds measured at 3 frequencies in both ears after 1,2,4 and 6 hours of exposure and at 3 other frequencies	In only two instances the lean TTSiexceeded 3dB, being 4.6dB at 5.6KHz for the landings spaced 3 linutes apart and 4.3dB at	lack of hazard from aircraft noise is consistent with cross-sectional and longitudinal studies of the hearing of	frequencies tested an not mentioned. It is not clear as to

1	2	3	4	5	6	7	8
	noise.		or 3 tin.	after S hours of exposure.	*Hit* for landings separated by 1.5 mini1.	aircraft maintenance .personnel, which showed that even before the advent 0! mandatory ear prote-ction, only small permanent lossses attributable to the aircraft noise exis-ted despite the fact that very large TTS's were being produced.(Eopra, 1957; ward,1957, knight and coles, 1966).	why only three frequencies were tested at 1,2, 4,& 6 hrs and other 3 frequencies at 5 hours.
Dolan,T,B., Ades.H.I., Bredberg, G., Ieff,I,B., (1975)	To assess the daiage to the inner ear and hearing loss after exposure to tones of high intensity.	cats	Cats were exposed to tones of 125,1000, 2000, and 4000 Hz at SPL's in the range 120-157.5 dB and for durations one hour at 1,2&4KHz for four hours at 125Hz	Pure tone audiograis obtained before and after the exposure. Frequencies tested are 125,250,500,1000,2000, 4000,8000 and 12,000Bz.	Exposure to 4KHz pro-duced damage in a restricted region of the cochlea and hear-ing loss for a rela-tively narrow range of frequencies. Exposure to 125Hz produced vide spread inner ear damage and hearing loss through-out the frequency range of 125-6000Hz.	In considering the results of the pre- * many others that have related hearing loss to inner ear daaage, the limita-tions of Methods used in assessing inner ear daiage must be kept in lind lo histological technique provides a complete assessient of intracochlear damage or change resulting from an exposure.	The discrepancy betveen the damage to cochlea and hearing loss at 125 Hz and at 4 EEx may he due to the difference between the exposure duration.
Donald,1,1., Jane, B., Carol, T., (1978)	Due to the limitation on human research, this stud; xas condu-cted to determine which animal would he	5 sale squir-rel Monkeys aged 7-! yrs. Two of thea *r* made monoaural.	Exposed for 1,2,4,8 16,24 and 48 hours to a 375-750Hz band noise at an overall SFL of 95dB.	Thresholds were measured at frequen-cies 500, 750 and lOOOHz. At 4 4 16 hours of	TTS4.5 growth patt-ern for the 750Hz test frequency was biphasic and did not reach an asymptote	The results show that after exposure to a low frequency octave band of noise, the growth and reco-	To lake the comparison (between human *i* animals),

1	2	3	4	5	6	7	8
	appropriate as a model for human TTS.			exposure only 750Hz was tested.	after 41 hours of exposure. For all exposures, the lean threshold after 29 hrs of exposure,of five aonkeys returned t.within 5dB of the Mean pre-exposure thresholds. Increasiw SPL fron95-105dB in-' creased TTS«.j hy 4dB at 750 Hz for a lhr exposure. Recovery curves from all expo-sures at the 750Hx test frequency appea-red biphasic.	very of TTS in squi-rrel monkeys are sufficiently siailar to those in huaan subjects.	further eiperiaents should be conducted on a larger number of to subjects from both species, and the level of the exposure stiaulus reaching the inner ear should be considered.
Donald, B., Roger, F.B., Richard, J.S., William, A.A., (1983)	To determine how well the AEF thresholds agree with the beha-vioural thresholds when hearing is nor-mal & when there is significant amount of noise induced threshold shift.	3 noraal sale chinchillas in the range 2-4 yrs.	Exposed to conti-nuous noise of 95dB SPL at 2-4IHz coibi-ned with iapulse noise of 158dBSPL Exposed to 1 hour.	AEF aeasureaents at 0.5, 1,2,2.8,4,5.6 & 8 IBz. Behavioural measure-ments.	Pre-exposure audio-gram: All animials had hearing of less than 0.7dB. 1 day after exposure: Elevation of thres-hold at 2EBz and above (noraal at lover frequencies. 30 day post-exposure: One chinchilla shoied some PTS at high fre-quencies. The audio-grams of other 2 animals were about normal.	The close agreeaent found in this study betaeen the 2 aea-turss when the audi-tory systea is noraal, when there is a large high freq hearing loss *i* when there is a wild loss, indi-cates that the AEP is a legitiaate substitute for the behavioural audio-gram. Above 12-14Hz The AEF thresholds increase signifi-cantly *i* are auch higher than those measured behavio-urally. Thus one can not obtain useful inforaation on higher frequency	The threshold shift after lday exposure, was it the saae for all the 3 aniaals or us it aore for the one ihich developed PTS?

1	2	3	4	5	6	7	8
						hearing using the AEP.	
Donald, 1., Roger, P,H., Ronald, W,S., (1974)	l)To focus on soae of the problems encountered in developing impulse noise DEC. 2)To present newdata on the histological and anatoaical effects of exposure to impulse noise. 3) To relate these data to existing DRC.	24 Honoaural chinchillas ,	Subjects were exposed to either 166 (N=9), 161 (N=10) or 155dB (n=5) peak equivalent SPL iapulses which had an duration of lmsec.	Auditory evoked response at 0.25,0.5,1, 2, 4 and 8KHz. Tyapanoaetry using electroacoustic bridge (Grason-Stadler 1720 otoadaittance Meter).	155dB peak SPL produced essentially no PTS, but each animal shoved large and consistent outer hair-cell lesions, 6-llaa from the apex. At 161dB peak SPL, seme aniaals shoved no PTS and no haircell loss, while others had substantial PTS with Urge haricell loss. The 166dB group showed consistent mediun 5-15dB PTS with all aniaals having substantial haircell lesions. Tyapanometric results showed that 4 aniaals in the 166dB group had tympanic leabrane perforations that healed within several days.	The data of the present expedient suggest that there is a "Critical intensity[1] that is related to a conductive failure. If the rupture occurred early in the exposure, it would prevent efficient transmission of the sound energy, and, ultimately, protect the inner ear. Since there is not a consistent relation between hair cell integrity & hearing, the protective effect referred to above applies only to the haircell population. All three intensities produced unacceptable levels of TTS as defined by CHABA group i.e., an average of 15dB or greater at 1,2 i 4 lix (Kryter et tl.l966).	Not mentioned regarding the frequency of presentation of impulses. Not mentioned regarding the tympanometeric results of other aniaals.

1	2	3	4	5	6	7	8
Donald,H., Roger, P,B., Syracuse., Ronald, S., Geneseo., (1974)	To expose chinchillas to high level impulses deemed safe by existing standards and compare audiometric changes with the underlying histopathology.	5 nonoaural chinchillas	Chinchillas were exposed to 50 impulses of 155dB peak SPL and lmsec A-duration.	Pre-and post-exposure Auditory evoked response testing at 250, 500,1000,2000,4000 *i* 8000 Hz.	All animals manlfested large TTS of 30-70dB which recovered by 30 days. All animals had complete losses of outer hair-cells is the region 8-12MN fro, the apex.	Recovery froi continous noise is linear with the log of time, while recovery fromimpulse noise usually shows a rebound to higher levels of TTS before resolving to final threshold levels. This study shows the median time to maximumTTS is 3 hours. The results also pointout the need for a lore sensitive audionetric index of cochlear daiage.	Previous studies show that TTS does not cause hair-cell dauge and this study contradicts the previous studies. Further studies need to be done to study the relationship between TTS and haircell daiage.
Douglas, F.I., Tom, W.T., (1970)	To determine whether immediate sensitization is a real phaenomenon that can be demonstrated in the auditory behaviour of a group of subjects.	10 normal (7 males & 3 Females) adult subjects.	Expt 1: Exposed for 3 ain to 5OOHz exposure tones at 40,65 or 90dBSPL. Expt 2: Exposed to 3000Bz tone at 40,65 or 90 dBSPL.	Exptl: Threshold sensitivity for 200Hz tonalpulses. Expt 2: Threshold sensitivity for 2000Bz pulses [Tr=Subjects continue tracking threshold for the 200Bz pulses during the period in which the 500Hx exposure tone was present. DHTr= Subjects need not require tracking.]	Exptl: The 40dl SOOBz exposure tone has little effect on thresholds for the lOOHz poises in either the Tr or DITr conditions. Maximum sensitization occurs 30-50sec after cessation of the exposure tone and vanishes by about 1 min. Sensitixation Magnitude is fairly stall, its laxiiui being 3.2dB in the 90 dB DITr session. Expt 2: Demonstration of a period of sensitization is the only notable deviation	The term immediate sensitization is used to describe an improved post-exposure threshold sensitivity that is not preceded by desensitization, that grows to uxiiui size at about 40sec post-exposures, and that then disappears by about 1 lin.	Threshold sensitivity should have been done at frequencies above the exposure frequencies since the noise or tonal exposure causes loss at high frequencies.

1	2	3	4	5	6	7	8
					from pre-exposure performance is not restricted to low frequency conditions. Sensitization appears liter and is of lesser magnitude. 90dB exposure-tone produces less sensitization than the 65dB tone. Maximum sensitization at 2000Hz resulting from 3000Hz exposure tones is 2.6 dB and occurs 40sec after discontinuation of the stimulating tone in the 90dB-DITr session.		
Dunn, K.D., Davis ,1.1., Merry ,C.J., Franks,3X. (1991)	To determine whether exposure to impact & continuous noise Kith the sane acoustic energy and spectrui yields the saie effect on the auditory systea.	16 norial chinchillas of 9-12mth of age	Iipact noise: Banmering striking a nail with a peak pressure of 120dB SPL, the total duration was 116rms. Continuous noise: Pink noise. GPI: Exposed to 4hrs of continuous noise at 110dB for 5 days. GPII: exposed to 32656 impacts for 4 hrs for 5 days.	Auditory evoked response testing procedure Frequencies 1,2,4, & 8 kHz were tested.	Mean pre-exposure thresholds were within SdB for all frequencies. GPI:Exhibited a shift in hearing thresholds at all frequencies. GPII: Showed substantially nore hearing threshold shift than did the continuous noise exposed group at all test frequencies.	The differences note*1 in the resulting hearing loss is attributable to the differences in temporal characteristics of iipact S continuous noise. Majority of surveys indicate that iipact noise is lore hazardous to hearing than continuous noise.	Inittance should have been done to check for the middle ear involvement. The time gap between the exposure and the testing procedure is not mentioned. Threshold measurement after soie period of exposure could have given

1	2	3	4	5	6	7	8
				•			information aboat recovery.
Emilia, E., **(1974)**	To ascertain whether damage to the inner ear caused bj the ototoxic side effects of as antibiotic cre- ates a predisposition to a more rapid deve- lopment of hearing deficits due to industrial noise.	250 young Guinea pigs weighing 300-400 g divided into 4 groups.	Control animals*lO. Group I: subjected to industrial noise Group II: Given kanaiycin one week before the exposure to noise. Group HI: lanaaycin was given 2 weeks before exposure to noise. Group iv:recieved kanuycin for 2 weeks while being exposed to noise. Level of noise->92-93dB.Exposure dura- tion was 1-12 weeks.	Electrocochleogram,	Cochlear microphonics and Action potential changes occurred in phases but the dyna- mics of changes differed.Peripheral adaptation was pres- erved but deteriora- tion was seen.	The results confir- aed by statistical methods indicate that drugs with oto- toxic side effects lead to an earlier developaent of daaage to the ear by industrial noise, the daaage occurs with greater rapidi- ty if the drug is administered daring exposure to such noise. 1	A further study could be done where the daaage to inner ear can be checked after giving kanaaycin and before exposure to noise so that the exact effect of kanaaycin ON the inner ear could be cheeked, to find out the interaction effects.
Erick, B., **(1987)**	To determine haircell loss along the basi- lar membrane in rats after various tiies of exposnre (corre- late the morphologi- cal features to the degree of loss of auditory threshold sensitivity.	46 rats	2kHz wide band noise sweeping from 3-30 kHz at 105 dBSPL.	Thresholds deteriined with a behavioural technipe at 1.5,3,6, 12,24 & 48 kHz after 1,3,7 or 15 mths. ABS to obtain electro- physiological thres- holds, at 1.6,3.2,6.3 12.5,16 & 20kHz.	After lath, very little or no signifi- cant loss of hair- cells . Loss of threshold sensitivity was 25-40dB. After 3 aths: Modera- te loss of OBC (IHC. Hearing loss increa- sed only by about 10 dB. After 7 mths -Loss of haircells with loss of	In the present stu- dy, the progression of hearing loss and the loss of hairce- lls in prolonged noise exposure foll- owed separate tiae courses in rats. The time course of hear- ing loss correlates to observations in humans, where the hearing loss progr- ess rapidly in the	After 7athe 15 mths-The inforaation given is only about the loss of haircells. No inforaation about the degree of loss, whether it has reached

I	2	3	4	5	6	7	8
					threshold sensitivity at 3 to 24 kHz. After 15 mths-Loss of OHC progressed to a greater extent at 3-10KHz.	begining but increases at a slower rate after 10yrs (lixon *k* Glorig, 1961).	an asymptote level after 3 months of exposure. ABE results are not clear. Behavioural technique procedure is also not clear.
Flint.A.B., Richard,A,S., (1995)	To examine whether resistance to IIBL is related, at least in part, to changes in OHC function changes in lateral wall function or both.	20 normal mongolian gerbils of 6-I2mths of age.	Octave band noise centered at 4 kHz of 80dBSPL. 5 subjects -1 day 5 subjects -12 days Exposed to 6 hrs/day. 10 unexposed controls.	DPOAE. 2 sets of DPOAE data collected. a) eiissions at 8 points per octave over the range of 500-lOOOOHz at 50&60 dBSPL. b) input-output functions for frequency of 9500,8000,4000, 2000 i 1000 Hz. EPs collected from BV &1st 2turns of the cochlea in 3 subjects fro* each experimental group. EP->Evoked Potential DPOAE-)Distortional Product Otoacoustic Emission	The aaplitmies of DPOAE's were reduced in frequency range 4-10kHz in subjects exposed to noise for 1 day,but relatively noraal in subjects exposed for 12 days. DPOAE amplitudes from frequency regions below the spectrumof the exposure were similar across the exposure & control groups except at the LF edge of the noise where DPOAE aiplitudes were higher than normal in exposed animals. EP values in both exposure groups were - not reduced froi normal. No relationship between changes in the EP i the reduction of DPOAE amplitudes. Development of	Data reveals that resistance to HITS develops in parallel with changes in the susceptibility of DPOAI's to noise. Subraianian et,al (1993,1)94) have shown that following a single low frequency or high frequency noise exposure DPOAE's are reduced in chinchilla, but return toward normal as the exposure is repeated. Resistance to IIBL is exhibited both in changes in auditory sensitivity and in DPOAS amplitudes.	

1	2	3	4	5	6	7	8
					resistance to noisi is related to an initial depression of OHC activity.		
Frank,D.M., Charles,V.A., (1971)	To collect data on long ten TTS & TLS that could be directly compared, and to determine whether certain phenomena observed in prior TTS studies could be observed in TLS when all measurements were obtained under similar conditions.	5 normal adult tales.	Exposed to lOOOHz pare tone at 50,10 & HO dBSPL for a duration of 5 min.	Bekesy type tracking procedure at lOOOHz and HOOHi before and after the exposure.	Analysis of the results indicate that when TLS is leasured at constant level (30dBSPL), both its growth pattern and its recovery pattern are siiilar to those of TTS, but when TLS is measured at the same level to which the car is exposed, its growth pattern and its recovery pattern are different from those of TTS.	The present results pointout rather clearly the similarity in growth and recovery patterns of TTS and TLS and the lack of similarity between these two indices and the TLS. The TLS results were discussed interas of two process hypothesis of recovery similar to that presented by Hirsh & Bilger(1955) as an explanation of diphasic TTS recovery curves. It us suggested that, when pre-exposure and post-exposure loudness balance involve the same group of sensory cells or nerve fibres which lay be affected by an exposure signal, the early recovery process may be relatively unaffected but the later recovery process is in some way retarded.	Not mentioned whether the recovery was comlete or not.

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Fredrick, L, Alf,A., (1983)	To determine possible individual differences in TTS after repeated controlled exposure to noninformative noise t to music with equal time,frequency *i* sound level characteristics.	10 (9aales I 1 female) normal subjects in tS-17 years age range. J	Exposed to 10 sin of recorded popiusic on 5 occassions. On other 5 occasions these subjects were exposed to a noise with level, frequency i time distribution characteristics,measured in octave band steps equal to those of the music.	Hearing thresholds on the left ear was established with a computerized sweep-frequency audioieter (Bekesy type) at Frequencies froi 1000 to 5000Hz. Audioieter calibrated in accordance to ISO 389-1975.	Most TTS sensitive frequency were 4-6kHz for noise t 4-5kHz for music. There was a larked discrepancy in lean TTS between the two stimuli for (subjects,whereas 4 subjects showed only slight difference. This difference was due to tore TTS after exposure to noise. Comparison of the mean noise &music TTS at each session revealed a less pronounced difference as a number of exposures increased.	The results obtained in this study do indicate a difference in TTS susceptibility caused by psychological factors. This statement is only valid if 2 exposurecan be considered equal in terms of physical energy properties.	MoreTTS is found due to the exposure to noise.So, should have mentioned whether the sujbects were music lovers or not,since, studies have shown that music lovers exhibited lesser threshold shift than the non-music lovers when exposed to loud pop music.
Fred, H.B., Robert, I.p., Mount, P., Mich., (1972)	1) To determine the degree of TTS,if any, produced by snowmobile engine noise on both drivers and riders. 2) To initiate as acoustic analysis of snowmobile engine noise interms of SPL measurements and octave band SFL.	17 subjects (12 drivers I 5 riders) Drivers age range was 11-33 years with mean age of 14 years. Eiders age range was 6-30yrs with mean age of 14 years.	Eiposed to snow mobile engine for 120min.	Puretone air conduction thresholds obtained using Beltone Model 10C at octave frequencies between 250 and 80001:.Post-exposure testing was done with a delay of 20-40 min.	All subjects exhibited marked TTS at frequencies above 1000H2. The greatest amount of TTS occurred at 4000Hz, Acoustic analysis of snowmobiles revealed that the noise levels exceeded damage risk criteria for two hours exposure. One snowmobile was found to produce as much as 13SdBA at full throttle.	The TTS data obtained in the preseit study suggest that snowmobile engine noise is potentially hazardous. Sound pressure levels produced by the larger snowmobile engine appear more intense than other forms of recreational and environmental noise. This study suggests that drivers 4 riders should wear	Level of noise exposure is not mentioned. Driven do get more exposed to noise than riders. So it is advisable for the drivers to use some form of EPD'S.

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						some fora of prot-ection when snow-aobiling, and gover-nmental public health officials should establish I aonitor safe aaxi-NUN SPL for snow-lobile engines.	
Gail, D.C., Joan, E.D., Harold, AfD. (1984)	The explore the rela-tionship between the TOM & TTS.	20(10 males & 10 females) normal adults,	Repeated exposure to 3 min, 110dBSPL white noise,	Audiometry using Grason-Stadler 1701 clinical audioaeter calibrated to AISIS3.6 - 1969. TOH aeasures obtained using frequency out-puts of the Hewlett-Packard wide Band oscillator t Grason-Stadler audioaeter.	Female subjects demo-nstrated greater Bean 1-kHz TTS than male subjects. Feaale subjects pre-sented better 4kHz threshold prior to their first exposure. Mean 8kHz thresholds were better prior to the 1st noise expos-ure than the 2nd exposure. Ho differ-ence was found for pre-exposure TOM scores. A greater aean TOM shift was found following the second noise exposure	Female subjects pre-sented greater TTS at 8kHz than their male counterparts. Greater TTS at 4Uz was observed in female subjects. Ho overall relationship was found between TOM scores I TTS. Pre-exposure thres-holds presented an inverse relation-ship with TTS.	The lack of inforaation pertaining to the relationship between TOM scores and NIHL limits the extent to which results of the present investigat-ion can be generalized to the case of NIHL.
George, A.L., David, C.H., (1971)	To focus on recovery records froa indivi-dual animals and humans exposed to impulse noise.	10 monoaural rhesus Monkeys.	Exposed to two noise conditions. 1)12 ain of HOdB continuous noise 2) Two 168-dB impul-ses from a spark generator. The two impulses were separated by luin.	Behavioural aeasure-aent at 1,2,8 1 14 kHz.	After exposure to con-tinuous noise, alaost all monkeys showed a TTS which recovered as a function of log time. Range of TTS at 4 Bin was froa 5-40dB, while the range of recovery tiie was froa 20ain-32brs. There was no evidence	The presence of several different patterns of recover1 has implications forr the use of TTS in the construction of damage risk crit-eria for hazardous noise exposure. when two uncorrela-ted processes are	

1	2	3	4	5	6	7	8
					of PTS. After exposure to impulst noise, soie monkeys shoved a TTS which recovered in an unusual tanner such as, the rebound, a simple recovery, a diphasic recovery, a delayed recovery.	responsible for TTS them a single leisure, such as the widely used TTSI, may not be an adequate index of their magnitude. Further systematic study of recovery from hazardous noise in men and animals is warrented.	
George, JL.L, David, C.B., (1971)	To focus on recover; records from individual animals and humans exposed to impulse noise.	39 nonal adult tales.	Impulse noise with the peak pressure level of ISSdB; A-duration, about 250/isec, E-duration, 4 asec, presented in groups of five or nore.	Pure tone audiometry using Budmose AEJ-4 automatic audiometer at 2kHz, 4kHz and 6kHz (left ear)	Both the 2 and 4kHz curves average out to approximate the simple M-type recovery, although the irregularities suggest the possibility of S-type TTS involvement as well. The curve for (kHz, suggests M and S involvement in that the TTS recovered to lOdB at 3 min and then rebounded to a maximum TTS value of 22dB at just over 15 min post-exposure. M -> Metabolic TIS S -) Structural ITS.		
George, A, L., David, D.L., (1973)	To relate the susceptibility to damage from impulse noise in chinchillas when compared to man.	5 Monoaural chinchillas-	Exposed to 1 to 4 impulses of 168dB peak SFL and SOjisec A-wave duration.	Behavioural audiograms at 0.75,1.5, 4.0, 6.0, 7.9, 11.0 14.5 and 16.5 kHz.	After exposure to impulse noise, all subjects sustained threshold shifts. Recovery tended to proceed as a logarithmic function of time after exposure. Co-	This present study oa the chinchillas' ear was done to learn more about the human ear,where the difference between man and chinchilla is a possible limit	Pre-exposure leisure of middle ear impedance defines the presence of middle ear

1	2	3	4	5	6	7	8
					chlear hair cell losses were stall and not significantly different froa those exposed to 10-40impulses-	on the usefullness of this species.	damage after the exposure.
George, A.L., John, L.F., William, J.F., Janes, D.H., (1980-86)	To study the relation between IIS & PIS in Rhesus monkeys exposed to Impulse noise.	10 aortal (5 tales and 5 females)feral rhesus macaque tonkeys is the age range 4-8years(tale) and 3-5years (female).	Exposed to continuous & impulse noise. Level of noise-110 dB. To induce TTS-2 impulses used. To induce PTS-lfl or 20 impulses were used. Exposed in the order-2 impulses-) tank noise->2itpulses->2 impulses-) tank noise.	Puretones generated by a Hewlett-Packard oscillator. Frequencies-1,2,4, 8,10 &14kHz. After continuous noise exposure only the 2kHz threshold was tested.	Pre-exposnre audiogru: 9 tonkeys had aortal hearing. One had high frequency hearing loss (55dB at 10 and 12kBz). lecovery after expolore to task noise: All subjects showed a logarithmic recovery. One showed a delayed recovery.7/5 subjects showed less TTS after the 2nd exposure. Group correlation between TTS on the 1st & 2nd exposures were negative. lecovery after exposure to the two-impulse condition: 2 subjects did sot recover to within 10 dB. One subject suffered a PTS of 35dB at 8kHz 4 another ISdB at 14kHz Threshold shift after 10&20 impulse conditions: Threshold shift deterained at 24 hr, 2,4,8,16 4 32 days following exposure. Median threshold	No significant correlation found between TTS produced frot an initial exposure to 2 impulses 4 the PTS seen at 64 days after was exposure to 10 impulses. Although large amount of TTS did not predict a large amount of PTS, it did predict the early developmeat of PTS. The correlation between TTS at different frequencies were cotparable to those found for humans exposed to the sate iipulse noise (Fletcher & Loeb 1965). Rhesus tmnkey appears to be lore susceptible than man to impulse noise 4 continuous noise.	The exact recovery duration should have been tentiond.

1	2	3	4	5	6	7	8
					shift was greatest at 8 or 10kHz during the 1st 8days, at 10 or 14kHz for the next 24 days. One subject had a rapid drop at 8kHz between 8 *i* 16 days. 2 animals had a clearly defined audiometric dip when tested after 64 days.		

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Gerhardt.I.J., (1979)	To measure changes in the dynamic properties of the acoustic reflex following sound exposure	8 young adult chinchillas.	Exposed to 0.5kHz octave band noise for eight hours at 95 dBSPL.	Acoustic reflex threshold measurement.	Thresholds of the acoustic reflex increased systematically throughout the noise exposure up to approximately 14d! after 8 hours of exposure.	The results indicate that the threshold of acoustic reflex was elevated following an 1 hour exposure to octave band noise. The teiporal pattern of the growth of the Reflex threshold shift followed the growth of inferred TTS upto 8 hours. Thus there is a strong' indication that the effectiveness of acoustic reflex as a protective mechanism for cochlear structures is reduced as noise exposure continues for a period of 1 hours.	Not mentioned regarding which frequency was tested for acoustic reflex threshold meassrement.
Gjaavenes, *I.*, Moseag, J., lordahl., (1974)	To determine the nunber of hearing lesions in school children caused by the noise from Chinese crackers on one single day.	791 nornal pupils (735 boys i 56 girls) in the age range 12-15 years.	Exposed to Chinese crackers for one single Norwegian Independence day.	Audiometric screening at 2,3,4 and (kHz Closed-spaced-Frequency (CSF) pure tone audiometry using Peters AP6 clinical audioneter.	Pre-exposure: 50 boys and 4 girls had hearing acuity at one or lore of the test frequencies of atleast 15dB. After the exposure soie of them had history of tinnitus. One girl & 9 hoys had hearing loss 30dB at one or more frequencies. CSF pure tone audionetry revealed that about 0.71 of boys acquired PTS.	The dips in the audiogram caused by the itpulsive noise are narrow with the dip maximum near & kHz. Therefore conventional audiometry lay fail to detect the hearing loss. A modification of the conventional audiometer by replacing the test frequency 6kHz by two test frequencies that trisect the	Level of noise is not given. Time gap between the exposure and testing is not Mentioned. Frequencies above 6kHz should have been checked to know the exact con-

1	2	3	4	5	6	7	8
						octave between 4 kHz and 8 kHz would increase the detective ability of the audioneter.	figuration.
Grenner, J., Hilsson, P., katbamna, 1., (1989)	To study the extent and spectral distribution of noise-induced threshold shift after steady state noise exposure.	(0 female guinea pigs weighing 200-250g.	Exposed to broad band noise of SFL varying froa 96 and 117dB. Exposure duration was varied fron 3 to 12 hours for 4-5 weeks.	Electrocochleography at fourteen frequencies at 1/3 octave band frequencies froi 20 to 1 kHz.	Thresholds were elevated at all frequencies with increasing SPL. maximum threshold elevation exhibited a slight shift toward higher frequencies. With increasing exposure tine, the threshold elevations increased and shifted into high frequency region. Linear regression analysis showed that the average threshold elevation between I and 20kHz did not deviate froa the predicted equal energy hypothesis. High frequency loss at 5-20 kHz was dependent on exposure time, where as l-4kHz loss was not.	The noise used in this study had a falling spectrua with lost energy in the l-3kHz region. Therefore direct coaparison with studies using pure tones, or octave band, white or pink noise cannot be lade. It is reasonable to assuae that the relative influence on the PTS that results froa exposure tiae and SPL may be equal is some aspects.	
Grenner, J., Rilsson, J., Katbamna, B., (1990)	To ascertain whether the thresholds in the right and left ears could he regarded as independent observations and to see if differences in skin pignentation Here	53 groups of noise exposed guineapigs with 5 animals in each group. 46 control animals.	Filtered squarexave clicksor hammer blo-HS or filtered BBS of 96-117dBSFL Exposure duration varied between 1.5 -24 hrs.	Electrocochleography. Frequencies tested 1kHz - 20kHz.	In noise exposed aniaals, the threshold elevations were upto 40dB. The average right-left correlation co-efficient within each group was about 0.79, reg-	The right-left correlation Bay be due to: The sound exposures must have been syaaetrica'l. Measuring technique aay influence the	

1	2	3	4	5	6	7	8
	associated with differences is the threshold elevation.	wt:200-500g			ardless of noise energy. The degree of correlation was significantly greater after iipact noise than after continoua noise, No correlation wat found between the degree of skin pignentation and the threshold elevation.	results.	
Hamerik, E.P., et al (198))	To investigate the role of the various exposure parameters while keeping the total acoustic energy of the exposure approximately constant.	82 chinchillas »ade monoaural by surgical destruction of left chochlea.	Exposed to continuous noise of 95dB at 0.5kHz octave band and iipact noise of 113,11} or 125 dB peak SPL. Vibration of 30Hz, 3grms and 20Hz, 1.3 grms. Exposed for 5days.	Auditor; evoked potential measurements at octave intervals from 0.5 to 16kHz t at the half octave frequency 11.2kHz (pre-exposure). Post-exposure-) Thresholds measured at 0.5 2 and 8kHz at 0,2,8,24 and 240br after reioval from noise.	There was no statistically significant differences between ATS or PTS caused by either of the two vibration conditions. Vibration alone caused very little or no sensory cell daaage. Iipact noise caused a lean ATS of approximately 30-tOdB at the three test frequencies. There was no effect of vibration on the ATS or PTS caused by 5kHz octave band of noise. There was significantly less PTS in the groups exposed to iipact noise and vibration than in the groups exposed to impacts alone.	Two vibration-alone exposures resulted in so significant audiometric changes in either'the lean ATS,PTS, Or percent sensory cell loss leasures. Three iipact noise exposure conditions produced the sate levels of lean ATS and no statistically different levels of PTS or percent sensory cell losses. -Addition of vibration to either the continuous or iipact noise did alter some of the dependent measures of hearing employed.	Human studies have shown that left ear is more susceptible to damage than right, ear. So instead of making the subjects monoaural, both ears should have been exposed to noise and a comparison made.

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Eamernik,P,1., Henderson, D., Coling, D., Salvi, R.,	To examine the potential interaction between low level iipact noise and Dhole bod; vibration for a prolonged period of exposure.	13 chinchillas divided into three groups.	Groupl-exposed to iipact noise of 113 dBSPL. GroupII- Vibration of 1grms. GroupIII- Exposed to iipact noise and vibration. Exposed for 10da;s.	For Group II aid III Auditor; evoked response thresholds were measured at frequencies from 0.5 to 8kHz Behavioural leasures carried out for Group I.	Pre-exposure:Auditory evoked response thresholds were 3-18 dB higher than the behavioural thresholds. Behavioural thresholds were normal. Post-exposure: Group I showed no perianent threshold shift and normal inner & outer haircells. Group II shoved a 35 dB ledian asymptotie threshold level at 0.5k8z & 43 dB at 8kHz. Above 1.4kHz there was a median PTS of 18-9dB. Group III showed asymptotic threshold shift at 0.5 & 8kHz of 44dBSPL i 53dBSPL respectively.	Kibration can influence the etiolog; of NIHL. Influence of vibration was not pronounced at lower frequencies. Vibration can potentiate the effects of noise on humans. [Temkin, 1933]	Auditor; evoked response was not done for group I *k* behavioural measures was not done for group II i III. Nothing is mentioned about the normative data. Behavioural measure procedure is not given.
Henderson, D., Eanersik.B,P., Hynson, L, (1979)	To study the hearing loss for simulated work-week exposure to impulse noise.	& monoaural adult chinchillas.	Exposed to a repetitive, reverberant, impulse noise for a total of five days, thr perday with the average peak over pressure was 113dB.	Auditor; evoked response testing at 0.25 0.5, 1,2,4 and 8 kHz, half hour before and after each of the 5, 8hr exposure was carried out. Final thresholds obtained 30 days post-exposure.	High frequencies such as 4 and 1 kHz showed a dail; ledian shift of 40dB and a 27 dB recover; before the following day's exposure. Low frequencies were shifted 35dB after each day's exposure with a 15dB recover; overnight. Final median audiograns showed little	The envelope of TS's can be thought of as a type of ATS. All frequencies are shifted b; approximately the sue amount by the end of the 5 da; exposure as the; were at the end of first days exposure, and as expected on the basis of the resu-	

1	2	3	4	5	6	7	8
					2 animals iere normal while the remaining 4 displayed l0%-40% losses in hair cells at specific cochlear sites.	et.al(l97l) there is so cumulative eff-ect. With two days recovery there is still some residual TS. The actual degree of oscilla-tion of threshold presuaably will be a function of the actual noise expo-sure as well as the acoustic environment during recover;.	
Hood, J.B., [1987)	Threshold shift following lain stimu-lation at varying intensities and CL. CL = Critical Level.	72 normal subjects in the age range 16-59 years.	lot mentioned	1st study: Peter's Audioaeter APS. Bekesy type track-ing procedure at 1kHz. 2nd study: Tested at 1500Hz. PTA & loudness dis-comfort level (LDL).	An inverse correlat-ion was established between hearing level & CL at same frequen-cy with a fall of 2.5 dB in the CL for every 10dB rise in hearing level. CL's measured half an octave above the fati-quing tone frequency was lower by 5-lldB. No correlation bet-ween TTS & hearing threshold level (HTL) As HTL increases, LDL falls- (CL:Critical level LDL:loudness discos-fort level. & HTL: Bearing Thres-hold level).	There are numerous psychoacoustical, histocbeaieal and electrophysiological studies which have shows that at inten-sities some 30dB or wore below the pain threshold, draaatic events can occur over a relatively narrow intensity range. a) a levelling off of the cochlear aicrophonic (Pickles 1982) b) Saturation of the hair cell responses (Russell Sellick 1978) c) a decrease in the cochlear action potential response (Toshie 1968) d) an abrupt phase change in the action	

1	2	3	4	5	6	7	8
						potential response (Eiang, pers.coma) e) a reduction of cochlear blood flow resulting in bypo-oxidosis of the organ of corti (Schnieder, 1974).	
Hotz, M.A., Probst, R., Harris, F$_f$P., Hauser, R., (1993)	To determine if the measurement of TEOAE's could be used as an objective field procedure, to_ look for significant changes in TEOAE during 17 wks of exposure i to coipare the sensitivity of procedure to that of pure tone audioietry.	147 noraals of age 20yrs S 23 years •	GpI-> N=117,exposed to noise intermittently frog weapon fire that included 300 rounds of aaaunition for their rifles, 2 hand grenades and tuo bazookas each. GplI-> n=30, noise exposure included 600 rounds of aiaunition for the rifles, 4,000 to 5,000 rounds of ammunition for the pistols, 4 hand grenades i 15 bazookas.	TEOAE leasured using ILO88 otodynamics analyzer hardware i software. Stiiulus- 80us clicks 3 Measures: * Echo level * Beproducibility * Response levels after bandpass filtering.	There was significant changes in response aaplitudes in the frequency range froa 2-4 kHz . Change in frequency range froa 0.5-2kHz were not significant for either group. Changes in relative amplitude did not exceed 15\ when spectra containing the lower frequencies were considered, there vas greaterthan 83% within higher frequency range.	The results revealed significant changes in the aiplitildes of the higher frequency components of TEOAEs occuring during the 17 week service period which is in contrast to the pure tone findings reported by Spillaan et al (1990) TEOAEs offer a sensitive Beans of aeasuring the effects of daaage froa noise exposure that cannot be detected with pure tone audioietry.	Frequencies only up to 4kHz is assessed. ln elusion of higher frequencies would iaprove the sensitivity of detecting early daaage from noise exposure. retesting for confiraation of findings, pretpost test audioaetric testing was not done. Control group vas not included.
Fabiani, X., Mattioni, A., Saponara, K., Cordier, A.,	To verify the noise induced changes in the central acoustic pathways using ABB	130 athletes (26 females; mean age 29.5 yrs and 104	14 (2females i 12 males) were professionals in trap shooting.	-Pure tone audioietry -ABB measurement -TEOAE measurement -Impedence audioietry.	Audiometric examination revealed 77/130 athletes had noraal bilateral hearing	The results confira ths possibility that noise induced deterioration involves	results of TEOAE and impedance audioietry

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(1998)	response.	males; mean age 31.4 yrs).	79(67 males i 12 females) experienced in target shooting. 32(20mles & 12 feiales) practising modern pentathlon. 5(males)practising triathlon.		thresholds. 53/130 had hearing loss of 30dB on atleast one frequency between 2 & 8kHz. Hearing loss was prominent in 3} athletes (Unilateral) and 11 nith bilateral hearing loss. 35/3) hearing affected athletes had & severe high frequency hearing loss. 32/70 ears did not show any involvement of retrocochlear auditory pathways. Among 38/70 ears, ABB were absent in 19 ears, and in 12 ears a damage of acoustic pathways was seen by prolonged wave 1 latency.	both central and peripheral acoustic structures as veil as the auditory brainstei. leverth-eless this damage is often hidden as the unique symptom of this multiple damage is only the hearing loss.	is not given. Frequencies tested are not tent-tioned.
Helstrom,P,A., Axelsson, A., Costa, 0., (1998)	To establish the noise dose fromtypical portable cassette players(PCP) use, and determine the auount of TTS resulting from the exposure and also to determine the individual TTS-susceptibility after noise exposure and related this to BUSK induced TTS.	21(13 males i 8 feaales) Normal subjects in the age range 13-30yrs and an average age of I5.3yrs divided into 3 groups.	Exposed to 1/3 octave band filtered pink noise with 2kHz centre frequecy at 105dBSPL for 10min. After 24hrs subjects were exposed to music for Ihr at their cosfortable level.	Bekesy audiometry.	Feiales had significantly more TTS than the tales after noise exposure. Most subjects had only discrete TTS after one hour of listening to tusic, inspite of 91-97dB listening levels. There was no significant differences in listening levels or music-induced threshold shifts between genders.	The stall TTS suggests that listening to comfortable levels over PCP for one hour is probably safe and without any risk for a pertanent noise-induced hearing loss, provided that the levels and duration are not higher than in this investigation. There was no correlation between the subjects sensi-	Frequencies tested are not mentioned. Comparison could have been done lith nonmusic lovers.

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						tivity to noise & music.	
Humes, K.L., Schwartz,M.D., Bess, H,F., (1977)	To examine the hypothesized relationship between the onset of Basking at harmonic intervals and lonoaural post-stimulatory fatigue.	9 nomls{2 males and 7 feiales) is the age range l!-27yrs and mean age of 22.9yrs.	Monoaural exposure to white noise at 110dBSPL for 5ain.	Measurement of: -Threshold of octave masking test (TOM) at 4kc/s. -Post-exposure, fixed frequency Bekesy tracings at 4kc/s for 3iin.	Masked thresholds at 8kc/s ranged from below 60-80dBSPL for the 4 kc/s aasker. Pure tone octave Basking grew in a linear Banner for each subject. The mean slope of the Basking growth function was 2.6dB Basking per 1 dB of Baskering intensity. Linear relationship exists between TTS_2 IS and TTS_2 Vs 4kc/s such that, as the threshold of octave masking increased, the auditory fatigue decreased.	Results reveal that the TOM test can effectively differentiate aaong individual differences in susceptibility to noise induced TTS. In addition to test retest reliability of the TOM test, this procedure is a well suited method for the assessment of susceptibility in untrained listeners.	Further study is required to test the generality of the findings of this investigation prior to the use of the TOM test in hearing conservation progrms.
Ivan,M.H-D., Donald,I.E., (1972)	To investigate the possibility that, even though PTS do not occur, haircelIs are, infact,damaged or destroyed by multiple TTS's.	14 normal young Bale squirrel monkeys.	6 animals vere exposed to 120 dESPL stimulus to create PTS of 10-20dB. 6 other aniials were to fatiguing stimulus for a period designed to produce a TTS of I5-20dB.	Behavioural measurement (avoidance conditioning procedure).	There was no clear evidence of hair-cell daiage due to exposure. Ho differences between control and experimental ears were noted in either apical or basal extremities of the 12 cochleas.	The results of this study imply that pure tone stiaulation sufficient to produce PTS's of 10-20dB may not produce anatoaical injuries to the organ of corti that are detectable by phase microscopy.	
Ivan, M.H-D,, Donald, I.E., (1973)	To investigate the hearing loss-hair cell damage relation-	5 squirrel sonkeys.	One animal was exposed to lkHz tone at 130dBSPL for 4hrs.	Behavioural aeasure•ent.	Wide variations is hearing losses and haircel1 daaage were	Ward & Duval1(1971) suggested that if inner haircelIs	Frequencies tested are not

1	2	3	4	5	6	7	8
	ship in squirrel monkeys exposed at intensities greater than 120dB.		Two were exposed to a 1kHz tone at 140 dBSPL for 3 and 4 hrs respectively. Two were exposed to 2kHz tone at 140 dBSPL for 3 and 4 hrs respectively.		found, and were unc-orrelated. Bearing losses ranged froi lessthan 20dB to greater than 50dB. Hair cell daaage ranged froa no app-arent damage to coa-plete loss of outer and moderate loss of inner cells.	are undamaged, normal thresholds aay be retained, even with loss of the outer haircells The data in this study do not support this suggestion. There is no consis-tent relationship between stimulus intensity/duration and histological findings.	Mentioned.
Janes, J.D., (1985)	The need for including the interoctave frequency at 6000Hz in routine audiological testing performed in hospital clinics and doctors offices inorder to identify hearing loss earlier.	76 adults	Employees exposed to high intensity levels of noise in certain work loca-tions.	Thresholds obtained following a quiet period of atleast 14 hrs. Otave Freguency-250Hz through 8000Hz inclu-ding 3000 & 6000Hz.	53 subjects demons-trated sone degree of SI hearing loss.11/53 showed hearing loss only at SOOOHz. These 11 subjects had normal hearing at 4 4 8kHz but had a loss of40dB at 6000Hz The group with hear-ing loss only at 6000Hz were signifi-cantly younger than the group with hear-ing loss at other frequencies.	Threshold inforaat-tion at 6000Hz in the present survey did serve as an early indicator of NIHL. This conclu-sion of the inter-octave frequency appears to be of particular iaport-ance when there is an history of prol-onged noise exposure on the part of the subject.	Nothing is mentioned regarding the thres-holds of the other 42 subjects and their audio-metric con-figuration. Level and duration of noise exposure is not given.
James, C.S., John, H.M., Jaies, D.N., (1977)	Study is concerned with the problei of intermittent noise exposure on the growth of threshold shift (TS) and its recovery.	8 monoaural (4 males and 4 females) chinchillas, aged between 3 4 5 years.	Chinchillas were exposed to 6 hrs. of noise, repeated for six levels (57-92 dBSPL) of an octave band noise centered at 4kHz .	Thresholds were obtained at 0.5, 2, 5.7 and 8kHz.	TS reached an asyap-totic level after the first or second exposure. ATS measu-red at frequencies exhibited greatest shift at 5.7kHz. ATS< was smaller for 6hrs. than continuous expo-	The data presented here provide evide-nce that the quan-titative relations between the paraae-ters of noise expo-sure and the resul-ting TS may be easier to unders-	

1	2	3	4	5	6	7	8
					sures by about 5dB. Decay of TS was nearly cotplete after 18 hrs. of quiet for the lowest levels of noise and nearly complete only after 3-5 days for the intermediate levels of noise. Snail amount of PIS were observed for the highest levels of noise.	tand when the TS's have stabilized after a number of noise exposures.	
Jaaes, E.P., Hilton, R.H., David, J.A., Ann, A., Mich., (1974)	To study the cochlear electrical activity in monkeys exposed to octave band noise.	Monkeys.	Exposed to octave bandnoise.	Cochlear microphonic and action potential responses to pure tone bursts.	Behavioural pure tone thresholds were within 3dB of cochlear action potential thresholds before noise exposure During recovery the action potential thresholds were as luch as lOdB lower. Input-output functions for the cochlear action potentials during these recovery periods strongly resembled loudness recruitsent functions and maximun voltages obtained frequently exceeded pre-exposure levels.	Reasonable explanations for post-exposure loudness recruitment exist, but the basis of the marked transient increase in cochlear electrical activity is still open to speculation.	The nuiber of subjects, duration i level of exposure, and the frequencies tested are not mentioned.

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Jerry, L.F., Paul, J.A., (1982)	To learn more about age effects by integrating into a single study observations of the initial effects of noise exposure & the time course of post-exposure threshold changes.	160 lice divided into exposed and control groups of 18 & 28 days old.	Exposed to high pass filtered noise with a low cutoff frequency of 4kHz. Major peaks was between 4 t 20kHz. Exposure duration was 10ming and intensity of either 115dB or UOdBSPL.	Threshold of auditory componnd action potential estimated fro* scalp-recorded electrical response.	The lean threshold differences was greater for 21 day old than for 11 day old subjects exposed to 115dBSPL nose. mean threshold diffreaces was greater for the 18 day old than for the 28 day old subjects exposed to UOdBSPL noise. Analysis of threshold differences revealed a significant three-way interaction among age, expsoure intensity and post-exposure time, An age effect is seen only at 120dB SPL and only after a 30- day post-exposure interval[. Individual data suggest that the existence of an age effect is deterined not by the initial post-exposure threshold bulr rather by subsequent changes in the threshold following exposure.	Data suggest that the apparent dependence of susceptibility on age is influenced by the particular charges of exposure level and by the interval between exposure and the threshold measurement. Age was not significant factor in determining susceptibility only then the higher of two exposure intensities was administered and then only after a 30 day post-exposure interval.	
John, L.F., Adrian, B.L., (1967)	To study inpulse noise induced acoustic trauma resulting from exposure experienced on one day (or less), on a firing range.	Young sale soldiers with bilateral severe hearing loss.	Exposed to rifle firing.	Pure tone AC and BC thresholds. Intelligibility testing using Beltone ISC or Beltone ISA audioieter. Bekesy audioietry using Grason-Stadler	There was rapid recovery from Day O-Day l at 0.5, 1, *k-mzi* less rapid recovery at higher frequencies. By the end of two weeks, recovery was complete for	Recovery at the speech frequencies O.S-2kHz was complete in about two weeks. There was no apparent correlation between the PB	Not mentioned regarding the level of noise exposure. number of subjects are

1	2	3	4	5	6	7	8
				model B-800.	frequencies from 0.S through 2kHz. On examination, showed continuing recovery for frequencies higher than 2kHz upto a maximum of 6months. Some residual loss was seen at 4 4 6kHz and perhaps a little at 8kHz.	scores and the degree of hearing loss. SIT followed tbe average loss in the speech frequencies. Symptoam of tinnitus and stuffiness in the ear often persisted beyond complete recovery in the speech range.	not given.
John, F. B., (1567)	This study attempta to answer -Is there a relation between frquency discriaination and the temporal changes in the threshold of audibility produced by noise exposure? -What effect does the level of the test stiauli have upon frequency descrimination following noise exposure ? What effect does a change in the frequency of the test stiauli exhibit upon frequency discrimination ?	10 normal hearing subjects -	Exposed to 6kHz LPF thermal noise at 110dBSPL for 10min.	Measures of threshold and frequency discrimination at 1k,2k and 4kHz. Post-exposure discriaination test stiauli were presented at 10 or 40dBSL.	When test stiauli were equated interms of SL, no differences between pre-t post-exposure Jnd's were noted at 40 dBSL or greater at any frequency. At low stimulus SL i.e. 10-20dB a differential effect on the jnd occurred due to noise exposure that was not explainable interns of TTS. At 4kHz therewas little difference between pre-4 post-exposure jnd. kt. At lkHz,the post-exposure! Jnd's were about 40% greater than pre-exposure Jnd. (Jnd's-Just noticable differences).	Threshold shifts produced by noise exposure are aaxiaal at relatively high frequencies where as frequency jnd shifts are most pronounced at lower frequencies. For the sate stiaulus conditions, subtle mitochondrial changes occur in the outer hair cells of the apical portion of the cochlear and are assumed to extended into the aid-frequency region.	So explanation is given regarding differences in Jnd's pre- & post-exposure. Gap duration between the cessation of exposure I the test procedure is not Bentioned.

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John, M.B., David, J.L., (1971)	To compare tbe TTS produced by a low frequency pure tone with that produced , by a low frequency band of noise in subjects with and without a leasurable acoustic reflex.	6 stapedectomized subjects and 6 normal subjects.	Subjects exposed on separate occasions to a 710 Hz pure tone and to a 1/3 octave band noise Kith an upper cut-off frequency of 710H2. Exposure duration Mas 10min at 110dB SPL.	-Bekesy audiometry at 1000Hz.	For the normal subjects, the puretone produced a TTS_2 of 18dB where as noise produced a TTS: of only 8dB. For the stapedectomized subjects, the TTS_2 produced by purs tone and the TTS2 produced by the noise is about HdB.	The results support the hypothesis that low frequency pure tones produce more TTS than low frequency bands of noise because of the differential effects of the acoustic reflex in responding to these two types of sounds.	
John, H.M., David, J.O., Burdick, *C.K*., Patterson,J.H., Mozo, B., (1983)	To study the TTS produced by exposure to low frequency noises in young adults.	V 52 normal aale students in tbe age range 18-22 yrs divided into 3 groups.	Groups of subjects exposed to octave band noise centered at (3,125, or 250Hz for 8 or 24 hours at levels 84dBA and 90dBA.	Sweep frequency Bekesy audioaetry using Demlar,Model 120.Below 250Hz, i.e.,at 90, 125 and 180Hz, auditory sensitivity was aeasured by fixed frequency Bekesy audioietry using Grason-Stadler model E800.	For 24hr exposure at 84dBA, TTS increased for 8-12hr. Although TTS was lessthan 20dB, complete recovery for many of the subjects required as long as 48hr.For 8hr exposure at 90dB (A) TTS increased throughout 8hrs exposure. TTS from the 90dBA noise for Shrs extended the TTS produced by the 84 dBA. Recovery from the 24hr exposure required as long as 48hr whereas recovery from the 8hr exposure required only 12-24hr For 250Hz, TTS increased about 1.5dB/dB increase in noise level, whereas for S3 i 125Hz conditions TTS increased less than 1dB/dB increase	Previous TTS data from huaan subjects exposed to noise for 4-24hr (Hills at.al. 1979; Patterson at.al 1977) suggest that TTS would increase for about 8-12hr and then reach a plateau asymptots. The present data are consistent with the results of previous experiments.	-High frequencies could also have been tested.

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					is noise level.		
John, W.C., Khader, J,A., Geary, A.M., Donnell, J.C., (1988)	To compare cochlear microphonic thresholds in older albino & pigmented guinea pigs both before & following exposure to noise.	9 normal albino and 9 pigmented guinea pigs of 14mths of age.	Exposed to BBH calihrated in a closed system to equal 126 dBSPL for 45 min.	Pre-exposure-> Thresholds for the first detectable elicitation of CH were determined for 3 pure tones 4000, 2000 & *1000*Hz. Pure tone stiiuli xere generated by a function generator. 90 min after stopping the noise exposure, CM thresholds were leasured at each of the 3 frequencies. Threshold for the first detectable elicitation of CH for 3 pure tones were recorded prior to, at 90ain *k* at 7 days after a 45 min exposure to 126dB SPL. Before exposure to noise, thresholds for pigiented guinea pigs were 24dB higher than those in albinos. Following noise exposure, the pigiented animals showed less than half the aiount of threshold shift displayed by the albinos. This change was attributed to higher pre-exposure threshold in the pigaented guinea pigs.	The differences in threshold between albino and pigiented aniials were strain specific and not principally due to variation in cochlear pigmentation. Decreased auditory sensitivity with aging has been associated with increased pigmentation of stria vascularis. (Strain:albino and pigiented aninals were of different genetic strains).		

1	2	3	4	5	6	7	8
				Both groups of animals displayed significant elevation in CM thresholds when measured 90min and 7 days after noise exposure. CM=Cochlear Microphonic NCR-National Cancer Research			
John, L.F., Michel, L, (1967)	To describe the TTS with peak intensity of impulses kept conslant, MIth subjects exposed to two different pulse durations.	67 normal hearing subjects.	Impulses generated at two durations (36 & 92 usec) by R.I. Benson and Associates spark gap generator with a peak intensity at 166dB SPL.	Bekesy type pulse audiometer at 12 frequencies froi 0.25-8 kHz and at IS pulsed frequencies from 4-18 kHz.	More than 2/3 of subjects had TTS exceeding 20dB within 10-25 rounds for the 92 jusec duration, shifts being especially pronounced at 4 kHz and above. Approximately half of the subjects shifted 20dB or aore when exposed to 75-100 impulses at 36jusec duration. For both duration, TTS Has lost pronounced at 4kHz and above though some shifted at each test frequency with tore shift at lower frequencies.	Approximately equal number of subjects had coaparable TTS's with 10-25 iapulses 92-,usec & 75-100 impulses at JGusec duration. With longer duration there is more TTS at the lower frequencies, but for both durations a very broad frequency range is affected.	Not mentioned as to how many impulses the subjects were exposed to.
John, H.M., Roy, W.G., Charles, S.W., James, D.M., (1970)	To describe the effects on the hearing of nen of exposures to noise with durations as long as one or two days.	28 year old norial tale.	Exposed to two occassions to an octave band noise centered at 500Hz first at 48 hrs at 81.5dBSFL i 29.5hrs at 92.5dB	Bekesy audiometry at 750Hz. Evoked response audiometry.	TTS measured after 4 tin of quiet (TTS<) increased for the first 8-12hr of exposure and then regained constant as the	It is clear that TTS reaches an asymptote in the case of aan as in the case of chinchilla. The time to reach asymptote	

1	2	3	4	5	6	7	8
			SPL after 5 weeks.		exposure was continued. At 750Hz, the value of ITS* asyaptote was 10.5dB for 81.5dB exposure and 27.5dB for 92.5dB exposure. Recover from TTS required 3-6 days. While ITS was present (a) Time constant of TI was reduced at 750Hz- (b) There was delayed recruitment of loudness. (c)Aaplitudes of Bekesey tracings reduced, (d) Frequency discrimination was unaffected (e) Threshold shifts measured by evoked response audionetry approximated those measured behaviourally.	appears to be froa 4-12hrs for aan. Also, the recovery from asymptotic TTS is SLOW. Atleast for frequencies is the region of greatest TTS, TI at threshold is altered.	
John, HM., Warren, Y.A, Robert, M.G., (1981)	To study the TTS produced in human subjects by exposure to a wide band noise,	42 normal (25 females and 17 sales) subjects in the age range 18-22yrs.	Exposed to a wide band noise for 24 or for 8 hrs on consecutive days, Vide band noise Mas coiposed of octave bands centered at 0.5,1,2 and 4 kHz .	Sweep frequency(Bekesy) audiometry using Dealar, model 120 at frequencies 0.25-8kHz.	For the 24hr exposure, TTS increased for about 8hr & then reached a plateau or asymptote. TTS's at asymptote increased about 1.7dB/dB increase in noise level above about 78dSA.	TTS produced by single octave hand exposure were used to predict the TTS produced by the vide band exposures. Predictions vere based on the "Istensity Rule". There is a reaarkable coincidence between the relation which describes ATS and noise level, and the	

1	2	3	4	5	6	7	8
						relation which describes IIPT5 and noise level. This coincidence and animal data are used to support the hypothesis that TTS grous to an asyiptote rather than a plateau, and that TTS at asyiptote produced by a given sound is an upper bound on any FTS that can be produced by that sound.	
Johson, A.C., Juntunen, L., Nylen, P., Borg, B., Hoglund, 6., (1988}	To detect the effect of interaction betneen noise and toluene on auditory function.	29 tale sprague-Da«ley rats divided into 3 groups	Group I:n=8,exposed to soise for 4 Keeks Group T:n=12,exposed to Toluene. Group T+N:n=9,exposed to Toluene followed by noise. T=Toluene N=Noise.	ABE recorded 2-5 days after the exposure. Frequencies tested -> 1.6, 3.15,6.3, 12.5 *i* 20kHz.	High frequency auditory impairement was observed after exposure to T alone I I alone. A slight recovery was recorded one i six lonths after T exposure. T followed by I resulted in a higher threshold at all frequencies. Slight recovery was recorded 6 lonths post-exposure. The threshold shift exceeded the sumnated loss caused by T alone and N alone particularly at 3.15 i 6.3 kHz. Latencies varied only slightly.	T alone *i* I alone caused a considerable decrease in auditory sensitivity of rats, particularly at high frequencies. The decrease in auditory sensitivity in rats exposed to T folloved by 1 was greater than the suuated effects of T alone & 1 alone at frequencies 3.15 -6.3kHz. The sensitivity inproved only slightly 6 months after the end of all exposures, indicating that irreversible damage had occurred.	

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Johnson, A.C., Hylen, F*; Borg, !.1 Hoglund, «., (1990)	To investigate the effect of the exposure protocol on the hearing loss caused by sequential exposure to noise (I) 4 toluene(T).	49 normal rats of 5 weeks of age.	l)Control group:n=10, not exposed to I or T. 2) Noise:n=10, exposed to frequencj nodulated I for 4 weeks. 3) Toluene:n=lO, exposed to T for 2 weeks. 4) n=10, Exposed to H for 4 weeks followed by T for 2 xeeks, 5)n=9,exposed to R for 4 weeks. Best for 4 weeks, then exposed to T for 2 weeks.	Auditory Brainstei Response measurement. frequencies tested: 1.6,3.15,i,3,12.5 and 20kHz. Loss of auditory sensitivity at each frequency = Average threshold of ABR in the unexposed control group-Threshold of the ABR in each exposed rat of the sane age.	The sensitivity loss after exposure to I folloved by T was greater than that recorded after exposure to N alone or T alone but did not exceed the summated loss caused by 1 alone or T alone at any frequency.	The results confira previous observations.	Since the thresholds for groups 3,4 and 5 were measured 1-3 weeks after the end of exposure, there could be a possibility that SONS amount of recovery would have occurred which is not mentioned.
Joseph, A., Hiriaa, F., Vladiair, F., Hit, 1.l Gil, H., Ian, B., (1995)	To investigate the relationship between click evoked otoacoustic emissions & hearing threshold, 4 its relevance to clinical audiology.	27 normal subjects of 18 • 0.5 years of age and 102 normal subjects of 29.9 I 8.3 years of" age.	102 subjects (GroupB--6) exposed to military noise of both an iipulsive 4 continuous nature for atleast S-13yrs. -Group A-Not exposed to noise.	Audiometry(GSI-U) AC->0.25-8kHz. BC->0.25-4kHz. CEOAE elicited with ILO 88 otodynamic Analyzer.	CEOA! levels decreased as the hearing threshold increased at frequencies 1,2,3 4 4kHz. Frequencies where hearing thresholds were worse than 20dBBl, CEOAEs could not be recorded. Even at frequency where the hearing was OdBHL eiissions were not always observed.Hoise exposed noraal hearing subjects had reduced overall CEOAE power with a narrow frequency range as compared with noraal	Lack of emissions observed in ears with hearing thresholds oi OdBHL aay be a sign of cochlear dysfunction, lost probably caused by exposure to noise. Absence of rscordabli emissions in the external ear canal Bay not necessarily indicate a total loss of OBC motility but rather only a small loss.	

1	2	3	4	5	6	7	8
					hearing, non-expossd to noise subjects. Presence of CEOAEs suggests hearing thresholds of 20dBHL or less at corresponding frequency. CEOAE-)Click evoked otoacoustic emissions.		
Julia, D.R., Larry, 1.1., Head, C,K., (1991)	To determine whether the Chicago ayaphonj orchestra players face a significant risk of developing NIPTS in their profession.	Koraal hearing subjects.	Leq values ranged from 79-99dB-Awtd SPL with a Bean of 89.9dB (A). Corresponding 8-hr daily Leq ranged from 75-95 dB(A) with a mean of 85.5dB (A).	Audioaetry using Medical Dimensions otoaatic units. Beltone 9D audioaeter. Calibrated according te AISI 3.6-1989.	Mean HTL's for 59 Musicians were better than those for an uns-creened nonindustrial noise exposed popula-tioa and only slightly worse than 0.50 fractile datt for the ISO 7029 (1984) screened pres-bycusis population. 52.5% of individual ausicians showed notched audiograms consistent with HIHL. Violinists i violists showed poorer thresholds at 3-6 kHz in the left ear than the right ear. BTLs were found to be better for both ears of ausicians playing bass, cello, harp or piano and for the right ears of violinists and violists than for their left ears. For 32 ausicians for	The findings reveal a small uount of NIPTS for a popula-tion of musicians of average suscept-ibility to noise damage based on 15hr per week of on the job noise exposure at the typical levels recorded during rehearsals and performances. Billion et al., (1988)-) earplugs with attenuation which is flat across frequency is tore acceptable to ausi-cians than conven-tional devices, which provide attenuation of high frequencies.	

1	2	3	4	5	6	7	8
					whom both HTLs and Leg were obtained, HTLs at 3-6 kHz were found to be correl-ated with the Leq aeasured.		
Iarlovich,R.S., Osier, B.A., Gutnick, 8,1., Ivey, 8,G.» Wolf, I., (1977)	To illuminate the relations between a paychoacoustic phenoBenon and acou-stic reflex behav-iour in response to pulsed stiiuli pres-ented successively over time.	7 Nornal young adults.	Exposed to continuous 1000 Hz tone at HOdB SPL for three ainutes. Broad Band noise presented to contra-lateral ear at lOOdB SPL which Has pres-ented continuous or pulsed Kith a period of either 360, ISO, 90 or 9 msec xith a 50% duty cycle.	Pre-and post-exposure thresholds tracked via a Bekesy type procedure for a pulse<1 1414Hz-test tone • Acoustic reflex thre-sholds leasured with an otoadaittance meter (Grason-Stadler 1720).	Noise presented to one ear with a 50% duty cycle i periods ranging from ISO to 360 msec is lost effective in reducing TTS generated by a 1000 Hz exposure tone. As the period of noise was decrea-sed or increased, TTS_2 progressively increased. Continuous as well as the 9 and 90 asec conditions were least effective in reducing TTS generated by the 1000 Hz exposure tone. It was hypothesized that acoustic reflex adaptation Bay account for the continuous condition results. TTS_2 was greatest for the controled condition and least for the 360 and 180 msec conditions.	The present results tend to support acoustic iapedance data (Mellis and wiley, 1975) and psychoacoustic data (Ahaus I Hard, 1975) suggesting that the reflex recovery times are less than one second, perhaps on the order of 500-600 msec.	
Kryter, 1,1., (1991) V****/	To study the effects of gun and railroad noise on hearing.	9771 adult sales	Exposure to gun noise and railroad noise.	Pure Tone audioietry at 500, 1000, 2000, 3000, 4000 I 6000 Hz.	Coaparisons of hearing levels, adjusted for nosocusis, of trainaen who had used no guns,	Small losses in hearing sensitivity at frequencies above 2kHz are	

1	2	3	4	5	6	7	&
					with the hearing levels of otologically and aoise screened •ales (Annex A. ISO 1999) reveal signifi- cant losses due to railroad noise. Addit- ional losses were found at high frequencies in traimen who had used guns. It appears that the effective Leq thr exposure level of trai- naen to railroad noise is about 92dBA and 87- 89dBA to gun noise.	found in traimen over the age of 45yrs. Rearing losses from railroad noise in trainien who had used guns are to a large extent tasked by or are not distinguishable froi, the losses due to the gun noise and vice- versa. Comparison of the aaounts of HIPTS found for the trainaen, with the aaounts of HIPTS estimated by proce- dures prescribed in ISO 1999, indicates that the effective exposure level, Leq 8hr, of the workplace noise of trainaen is of the order of 92 dBA, 87dBA for gun noise and 89 dBA for bunting and/or target gun noise.	

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Lei, S.F., Willias, A,A., Roger, P.H., (1994) \ * * * * /	To assess the application of frequency and tine douain Eurtosis to the assessment of hazardous noise exposures.	44 aonoaural chinchillas.	CNV:Broad Band gaussian noise (0.2-10kHz)J(t) = 3. CIYIiGaussian noise* impacts with peak SPL at 125dB. 3(t)=84 CNVII:Gaussian noise + noise burst having 106dBSPL.B(t) - 21. CHYIII:Gaussian noise + iipacts »ith energy at 1-4 kBz of 126dB peak SPL. J(t) 45 CIIX:Gaussian noise+ noise burst at 1104 dBSPL.B(t) = 10. Exposed for S days continuously.	Brainstea evoked potentials measured. Pre-exposure at 0.5-16kHz and 11.2kHz. During exposure at 0.5, 2 and 8kHz. Iwaediately after exposure at 2, 8, 24, 240 hour. Final audiograa 30 days after exposure.	CIVIII i IX had lover pre-exposure thresholds. Different frequencies showed different level of lean ATS. Coaparison of CIVI & CIVII revealed no statistically significant differences between two groups for the dependent variable of aean ATS. Mean threshold shifts for group CHVI t VII were siaiiar iaaediately after exposure ended.	Statistical properties of a signal are iaportant in the deteraination of hearing loss. Ihen the audioaetric and histological results are coapared to a aetric based upon kurtosis aeasured in the time and the frequency domain for each exposure, there is a clear indication that these statistical metrics are good predictors of the relative magnitude and frequency distribution of the threshold.	
Levine, S., Hofstetter, P., Zheng, X.Y., Henderson, D., (1991)	To assess the relative iuportance of the duration and peak noise in thlevel of impact tion of hearing loss. different levels of e produc-	36 monoaural adult chinchillas.	4 groups were exposed to 200 msec impacts at oneper second at 113, 119, 125 and 131 dB peak equivalent level for 7.5 hrs. 3 groups were exposed to 125 dB impacts for either 1.9, 7.5 or 30 hrs different durations.	Evoked potential recording.	Kith each dB increase, there was approxiaately 1.7dB of increase in hearing loss. For each dB increase in peak level above 125 dB, there was an average 6.6dB increase in hearing loss. The 125dB exposure is just below the critical level where the aode ofcocblear daaage shifts to mechanical failure.	The critical level, where the mode of damage to the cochlea changes froa aetabolic to aechanical is 120dB or greater and is related to the spectrum of the impact. Above the critical level, equal amounts of energy do not cause equal aaounts of hearing loss or cochlear haircell loss. At higher	Description of noise exposure in subjteras of how were present in each group is not clear. ects

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						levels, the equal energy hypothesis •ay not be practical for evaluating the hazard of impact noise exposures.	
Lilleior,R.M, Jansson, G., (1996)	A qualitative study to describe, froi the perspective of m e n with IIHL, their experiences of noise as a threat to health and their having to live with a hearing disability i.e. behaviours, thoughts and emotions in auditory demanding situations.	10 NIHL *o»en in the age range 46-71 yrs and lean age of 59 years.	Bean=18 yrs S.D =16.4	Fare tone audioietry at 20Q0Hz, 3000Hz, 4000Bz and 6000 Hz. Taped open-ended interviews.	PTA of 2, 3, 4 and 6 kHz was 59.6dB Hi in the better ear. Taped opts ended interview: 4 Categoriesi eaerged froi the data i.e. lack of awarness, ambivalence, controlling and avoiding coping strategies, stigiatization.	The results, although based on a restricted staple. •are bated on in-depth interviews. The saapling procedure resulted in a heterogenous group, intended to give a broad picture of the area under study. However, generalization to the population cannot be made, rather the results need to be verified in a larger study.	The type of work a the type of noise should have been mentioned. The thresholds of the poorer ear is not noted. The individual thresholds of each frequency has not been given. The average of four frequencies are given. No indication as to whether the threshold shifts is due to noise exposure or other factors.

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Luis,D.B., Donald,H.E., Jerry, W.T., (1572)	To leasure changes of physiological potentials following exposures that had been demonstrated to produce consistant shifts of behavioural thresholds.	15 normal adult chin-chillas.	Exposed to octave band of noise centered at 500'Hz at 95dB5PL for a duration between 48 and 72 hours.	Cochlear microphonic (CH) respones and endocochlear poten-tials sere leasured about 5,24 and 48 hours after expo-sure in each of the three cochlear turns.	Endocochlear potentials were unchanged.Shifts of sensitivity for CH in the second and third turns showed the closest numerical correspondence to behavioural TTS. Loss of sensitivity for action potential was greater. Changes in visual detection levels for the averaged evoked responses were consis-tent Kith behavioural TTS.	The pathophysio-logy associated with asyiptotic TTS is aost proba-bly peripheral because the loss of sensitivity for CM in the second *i* third turns bears a closer nuierical correspondence to the TTS aeasured in behavioural exped-ients than do the Measured shifts of AP responses. Shifts in sensiti-vity for IP were far too large. Since these expo-sures to noise did not change the end cochlear potential disorder must be in the hair-cell aodul-ating mechanisa.	lot men-tioned regarding the CM at first cochlear turn.
Lynn, 1,1., Donald, H., Julie, S., Kalini, S., Saauel, S., Doug, 0., (1995)	To analyze the hearing threshold data to cos-pare the hearing loss aiong soldiers repre-senting different (1) race groups. (2) noise exposure groups. (3) durations of mili-tary service.	Normal hear-ing subjects in the age range 17-56 yrs.	High noise exposure HOSi: Daily noise exposure can range froa none to the entire 24 hr -conti-nuous & impulse noise. Low noise exposure MOS: Dot routinely exposed to noise. BOSs->Military Occupational Specia-lities.	Pure tone air con-duction audiotetry (Tracer EA 600AM Microprocessor single station audiometer)	Soldiers exposed to high noise level had poorer hearing than the group of soldierrs with limi-ted noise exposure.On the average a signifi-cant difference in HTLs aaong the race groups lith black soldiers hav-ing the lost sensitive hearing & white soldiers having the poorest. Subjects with greater	Results suggest that soldiers in the Armor, Mil-ler; and Infantry branches acquired significantly more hearing loss than soldiers who recieved lesser noise exposure. -Black soldiers had the aost sen-sitive hearing-	No.of sub-jects taken for the study is not aentioned. The freque-cies tested and the thresholds are not aen-tioned. Duration level of

1	2	3	4	5	6	7	8
					durations of ailitary service had the least sensitive hearing. -Differences in BTLs aaong race groups las dependent on the duration of ailitarj service.	Investigators have speculated that lelanin plays a protective role in preventing hearing loss (M a I Bocci,1967; Garber, Tamer, Creel I likkop, 1912). -Soldiers with upto 14 years of iilitary service had relatively norial hearing.	noise exposore is also not given.
Malini, S., Donald, H., Vlasts, S., (1994)	To aeasure the changes in 2f1-f2 DPOAS's during interrupted noise exposures i to coupare these changes with changes in evoked potential thresholds and changes in the status of OBC's.	6 adult aonoaural chinchillas weighing 650g - 800g.	Monoaural chinchillas exposed to an octave band noise centred at 0.5kHz at 9SdBSFL for *i* hrs/day for 10 days.	Evoked potential testing DPOAE measureaents. Frequencies tested- 2,4 and 8kHz.	Both evoked potential thresholds and DPOAE's effectively track the temporary changes associated fith interrupted noise exposures. However DPOAE's often recovered to their baseline even when there was a threshold shift greater than 25dB. At 5 days post exposure, both evoked potential threshold and DPOAE's were normal despite considerate outer hair cell pathology.	Pre-exposure data indicate that clear DPOAE's could be recorded from chinchillas ear canals. The amplitude of DPOAE's are considerably higher than those reported with human subjects. Slope of DPOAE functions are twice as much as those seen in buwast subjects.	Normal DPOAE'a may not guarantee normal cochlear status and therefore results of DPOAE measurement should be interpreted cautiously.
Halini, S., Lrnn B H.. Flasta, S.,	l)Do DPOAE amplitudes decrease (then recover at high frequency noise?	5 normal chinchillas weighing 650	Octave band noise centered at 4kHz at 85 dB SPL for 6hr/day for	Evoked potential S Distortion-Product OAE recordings iade	Both EPs & DPOAE's showed a worsening of auditory function after the 1st	DPOAE's have been suggested to be a good indicator of	Complete recovery light have occurr-

1	2	3	4	5	6	7	8
Donald, B., Hicholas,L,P (1995)	2) Is there a good corr-respondence between chan-ges in DP0IE's & changes in EP thresholds? 3) Is there a good corr-spondence between DPOiE's & changes in OHC following high frequency exposures	800 gas.	:10 days.	before the exposure *k* on days 1,2,4,6,8 *k* 10 of exposure. Final measureaent done S days after the last exposure.	exposure t then showed a progressive recovery toward baseline. lo consistent relation-ship between changes in EP thresholds & changes in DPOAEs nor were there any systematic changes in OEC's that correspon-ded with changes in SPOAEs.	the status of OBC's (Lonnhury-Martin & Martin 1990; Lonsbury Martin et.al 1991; Zurek et al,1982) and can be used to differentiate co-chlear from retro-cochlear lesions. According to Zurek et al(1982)DPOAE's are sensitive enough to reflect small changes in TS (Threshold shifts).	ed within S days after the last exposure. Measureaents could have been done daily to check amount of improvement per day.
Manfred, I., Earl, I., Alfret, *I.*, Freidrich,S. Peter, B., (1991)	The contribution of noise, head injury, *k* ear disease to hearing loss has been studied aainly on disabled per-sons with the aia of settling coapensation claims.	110647 subje-cts (88277 males and 22370 fe-'males)in the age range 15 -65 years.	Exposed to a aedian SPL of 90.5dB(A). 6.3% worked at SPL higher than 100dB(A) during the 3 yrs. Daily exposure time-> 8hrs. Total exposure time->0.5-45 yrs. Exposed to steady state noise & 7% exposed to impact noise.	Establishing Puretone hearing thresholds according to ISO/DIS 6189(6).	Hearing thresholds of males after a NIL of 85-105dB(M are higher if a history of ear disease, head inju-ry or tinnitus is given. In low frequency range the highest hearing thresholds were found when tinnitus coabined with a history of ear di-sease. 4kHz-> Combined effect of noise *i* head injury is more pronounced than the cosbined effect of noise & ear disease. (NIL = Noise immission level).	10) of the study group did not dev-elop hearing impa-iraent until the age of retirement, even after IIL in the range of 116-125dB(A). Another 10% of the study group developed hearing impairem-ent after 96-10SdB (A) and higher, & this groups because handicapped before the age of retire-ment.	No inforaa-tion about the kind of ear disease and head injury asd the condit-ion of the subjects during the study.

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Maurice, H.M., Hewton, J.C., (198))	A case report:A cerebello-pontine angle epidersoid identified in a noise exposed patient as part of an occupational hearing conservation program.	One male subject of 24 yrs. of age.	Exposed to 8SdBA noise for 8 br. time weighted average.	Audiosetry-Baseline & post-exposure • Otologic test. STAT. Stapedial reflex. BEEA . Electronystagmography. CTscan . MRI. Air cisternogram. Cerebral Angiography.	Base line audiogras-Normal hearing in frequency 500-8000Hz. Post-exposure-) Mild SN hearing loss in left ear with reduced Word discrimination score (164). 3kHz-10dB 4kHz-25dB 6kBz-30dB 8kHz-60dB. Otologic, head & neck findings Mere normal, Cranial nerves 111-XII were intact. STAT-) No tone decay in either ear. Stapedial reflex-) Ho response at any frequency on contralateral stimulation of left ear. BERA->Absence of wave 7 on left ear. Electronystagmography-) Diminished caloric responses on the left ear. CT scan of head-) Normal MEI-) 2.5 by 3.5 ca extra axial lass in left cerebello pontine angle. Air cisternogram-Air in internal meatus + lass in internal meatus was observed. Cerebral angiography-> Mass effect associated with an extra axial CP angle tass.	Miller, Doyle and Geier (1981) reported *i* cases with acoustic neurinoia and other VIII nerve lesions in employees exposed to noise levels sufficient to require an Occupational Hearing Conservation Prograi (OECP). The purpose of OHCP is to prevent SI hearing loss and to identify employees whose auditory and otic problems are unassociated with workplace noise exposure.	Duration of exposure to noise in teras of days is not given.

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Morata, T,C, (1989)	To explore the effects of simultaneous exposure to noise and carbon disulphide on workers hearing and balance.	Group A = 53 normal males in the age range 22-53 years Group B = 205 Dorsal tales in the age range 18-60 years.	Continuous soise-> 86-89 dBA. Level of Carbon disulphide-) 89.92 mg/m3.	Audioietry (Interacoustics AD17). Balance test to group A. Frequencies - 500, 1000 2000, 3000, 4000, 6000 t 8000 Hz. Aabient noise level was 25dBA.	Amoung group A, 71.7% of workers had hearing loss. Along Group B, 66.7% had hearing loss. Hearing loss increase to 46.7% and to 70.6% for the group exposed to 2 yrs and aore than 3 yrs respectively as the exposure tine was increased. Balance test results-> Groups with hearing loss failed the balance test.	Results showed high percentages of hearing losses that could be related with the work envi-[ronaent conditions. There is a great increase in the proportion of bearing losses from the group with less tha 3 yrs exposure versus those with longer exposure.	Balance test was administered only to Group A.
Michel, P., Henri, J.H., Jaaes, D., (1993)	To determine the feasibility of impleaenting computerized audiometry in various clinical groups, using the Battery of Basic computerized Audioietry Test (BOBCAT).	420 in 18-64 yrs age range. 36 in 65-80yrs age range. 12 in 7.5-12 yrs age range -	Average exposure to noise of 22.34 yrs.	Computerized & conventional pure tone audioietry at frequency 0.5,1,2,3,4,5 *6KHz* for AC and 0.5, 1,2 i 4 kHz for BC. Speech testing introduced as a part of a separate investigation. Impedance audiometry (Madsen ZS331)	Coefficients of reliability remained equally high across frequency regardless of degree of hearing loss and group. Group Means *i* correlations between conventional i Computerized audioietry indicated that the 2 metbods leasured pure tone hearing sensitivity with the same degree of accuracy, that is within + 0.5 dB. -Speed of execution was found to be slower using BOBCAT in particular noise exposed workers.	This study deaonstrates a striking similarity of outcome by both nasal & coiputerized procedures regardless of subject age, or degree or nature of hearing, loss. BOBCAT may be effectively applied to export clinical protocols to select populations which are typically served by screening programs.	The average duration of noise exposure is 22.34 yrs. This is not applicable to children aged between 7.5 - 12yr». -It is better & easier to use conventional audiometer than using a sophisticated instruent such as BOBCAT for bearing assessment

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							as both give alaost saie results.
Miller, J.M., Dolan, D.F., Raphael, I., Altschuler,8.A. (199!)	To determine the effect of a higher intensity of stimulation on the interaction of noise induced hearing loss with age and presbycusis.	31 normal & early presbycusis sale mice, divided into 5 noise exposed and 2 non-exposed control groups.	Exposed to broad band noise (0.5-40 kHz) at lOSdBSPL for 45 Bin.	ABE threshold measurement.	ABE threshold shifts and haircell losses which followed noise exposure increased with age in the noraal aice. Subjects showing early presbycusis showed an increased sensitivity to HIBL over noraal subjects.	The findings support the view that aging with or without hearing loss increased the sensitivity of the ear to IIBL. However, it seeas that other factors aay contribute to IIBL in the aniaals with preaiture presbycusis.	Pre-exposure thresholds should have been taken for both groups to coapare the threshold shifts.
Morata, T,C. et al,(1997)	To investigate the effects of occupational exposure to noise and solvents on hearing of workers.	438	levels of noise; Varehouse and health (n=41) =<85dBA T1A-Aroaatics, Paraffins (n=89) -- 85dBA TWA. Previously at aromatics (n=l9) -Ma. Shipping (n=0)ʳ<85 dBA TIA. Maintenance(n=180) =>£85dBA TIL Laboratory (n=69) <85 dBATVA.	Pure tone audiometry using Beltone 2000 at 0.5,tk,2k,3k,4k,Sk 4 8kHz. Imittance evaluation (Tyapanoietry,reflexes RDT,P¥T) using Danplex tyap 83. (SDT - Reflex decay test. P?T = Physical voluae test).	Exposed groups had significantly aore workers with high frequency hearing losses than the groups from the werebouse and health clinic or the group from the laboratory. Acoustic reflex aeasurements showed absence or elevation of the reflex, presence of loudness recruitment and the presence of acoustic reflex decay.	Aaong the studied groups, maintenance was the only department in which workers were clearly exposed to noise doses considered to be high enough to cause a hearing loss	Tyapanometry, physical vollue test results are not mentioned.
Fauli, E., Rannu, A., Juhani, E., Hartti, S., (1980)	To try to establish epideaiologic risk Units for iapulse noise	536 subjects in the age range 17-29yrs and lean age of 19.7 years.	Rot specified.	Pure tone audioaetry (AC)ttsiog HadsenOB-SO. Audioaeter Calibrated according to ISO 1964. Octave I selected aid-	97 had hearing loss on induction (18.1%). -11 cases had hearing iapairment of about 30dB at 3-4kHz.	-20dB was used as tbe screening liwit. -The aost important source of noise was the assault rifle.	The level of noise is not mentioned. The time duration

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				octave frequencies tested-) 0.25-SkHz.	-19 cases at 6-8kHz. -64 cases (66\) had unilateral hearing loss. -33 cases (34%) had bilateral loss -Most loss was found at high frequencies.	-Epideaiological studies and lore exact exposure investigations are seeded to define the limits of risk for iapulse noise.	between the exposure and the test procedure has not been indicated. BC thresholds •ere not taken. So the type of loss is not known.
Pekkarinen, J. Iki, M., Starck, J., Pyykko, I., (1)93)	(1) To develop a single number estimate describing cumzlative exposure to shooting impulses. (2) To revise an existing risk model for PTS induced in steady state noise. (3) To evaluate the efficiency of the new estimate by applying it to population of forest workers.	158 normals in 43 + 0.7 years age.	Sorkers were exposed to chain saw noise i shooting iipulses. Chain saw noise=l00 dB(A).Average duration of exposure l000hrs in a year was exposed to 16 years.	-Audiometry (Maico MA-19) at frequency -0.5,1,2,4 i 8kHz.	Hearing threshold level: Measured at 4kHz 2t.3+l.7dB. calculated at 4kHz= 27.6+ l.0dB. According to Robinson's model the hearing levels had a significant regression co-efficient at every audiometric frequency. Bearing loss at 4kHz is due to effects of Lesi & Lase Exposure to Lesi = Difference in hearing level was most prominant at 4kHz & 8kHz. (Lesi = exposure to shooting impulses . Laze - Noise emission level).	-Shooting impulses of weapons has been reported to be haraful for military personnel(Eryter i Garinther 1965; Salmivalli, 1967; Anttonen et al,1980) -Hearing deterioration has bees reported during mailitary training even when hearing protectors have been used (Riihikangas et al, 1980) -In the present study, the hearing loss was significantly higher in the forest workers with higher exposure to shooting impulses than in those with lower exposure. -Predominant hearing	Duration of exposure to noise perday has not been mentioned. was the audiological evaluation done only after 16 yrs of exposure? After 16yrs of exposure the loss at 4kHz is only mild.

1	2	3	4	5	6	7	8
						loss in the left ear has been suspected to be partly caused by exposure to hand held weapots.	
Price, G.R., Ransack, S., (1989)	To develop knowledge of the ear's suscep- tibility to a gun- fire-like impulse that had its spectral peak near 4kHz.	24 female cats weighing 2.5kg on an average.	Exposed to 50 impul- ses produced by a primer explosion at peak levels 135, 140 or 145dB.	Electrophysiological Measureient at freque- ncies 2,4,8 and 16kHz Measured 30min and 2 months post-exposure.	Losses were greatest at 4kHz, began to develop at 134dB peak pressure, and the iaaediate losses grew at a rate of about 7dB for every dB in- crease in peak pre- ssure. Energy requir- ed to begin producing a PTS was only about 0.0TJ/m^2.	Data from cat and previous studies on chinchillas indicate that energy does very poorly in ratins hazard across pres- sures. At high levels. some aetric other than energy will be needed to adequately represent the hazard	
Prosser, S., lartari, M.C., Arslan, E., (1988)	Gunfire noise associ- ated with hunting could additionally damage the hearing of workers exposed to occupational noise & the extent to which it affects the hearing.	82 male non hunters in the age range 25- 59 years with hearing loss. 133 male hunters in the age range 25- 60 years with hearing loss.	-Railway service=25 yrs Gunshots. Audiological evalua- tion done 12hrs after the work shift.	Pure Tone Audiometry (AC t EC) at Frequency 0.25,0.5, 1, 2,3,4 *k BkHz.*	Normal & hearing imp- aired subjects were equally distributed in both groups. -14.3% of H presented with unilateral hear- ing loss at 4kHz. NH had bilateral hearing loss. -Bilateral hearing loss->H showed asya- metrical thresholds *k* IB showed syaaetri- cal thresholds. Low \ of IH showed interaural threshold differences of + 4dB Higher % of H showed interaural threshold differences from 5 up to over 55dB.	Since the subjects did not use hearing protectors, a back- ground of occupa- tional noise may be thought to be res- ponsible for the bearing loss. The audiometric picture is also influenced by age. Hunters more often show asyametrical thresholds with worse hearing levels contralateral to the shoulder supporting the firearm. Shoot- ing noise does not seem to affect the ear ipsilateral to	Degree & type of loss has not been mentioned. Since the audiological evaluaition was done llhrs after the exposure, there could have been some amount of improveaent in the thre- sholds.

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					In both groups the hearing deteriorates with age as a consequence of combination of age 1 noise related factors. (IH-Non Hunters H- Hunters).	the firearm shoulder. Workers with moderate IIHL who practice bunting as a leisure activity aay develop additional hearing loss as a consequent to gunfire noise.	
Rackl, J., Newell, T.D., (1979)	To investigate the effects of firetruck engine and siren noise on the hearing of firefighters.	Group A:17 subjects in the age range 23-28yrs with a mean age of 24 yrs. Group B:17 subjects in the age range 30-35 yrs with mean age of 31.5 yrs	Groups:Firefighting experience from 0.75-2yrs (mean = 1.3yrs) Group E:Firefighting experience from 8.25 10.9yrs (mean = 9.1 yrs) SPL's of trucks did not exceed 90dB(A). Noise levels set ANSI specifications.	-Pure tone audiometry using modified Hughson Vestlake procedure.	Left-Right differences were not found. There was no significant differences between groups A and B, suggesting that 8-11 yrs of firetruck noise exposure did not significantly change the sensitivity of group B.	I)ata from Corso(1963) allow comparisons of groups A and B for persons with no known noise exposure. For both groups, the coaparisons of persons of the same age reveal significant losses at 0.5-4kc/s but not at 6 or 8 kc/s.	Frequencies tested were not mentioned. Jo significant differences between group A & B may be because the exposures met ABSI specifical time -ons. The work space noise levels net ANSI specifications and the exposures did not exceed OSBA regulations.
Raymond, B., Clauds, T., (197?)	To study the influeace on the effect of tenporal distribution of sound energy on growth and recovery of TTS, assuiing that TTS is an accurate	20 normal young adult tales.	Group l(n=lO)were exposed to steady state and to interaittent noises. Group 2(n=10) were exposed to steady state and to the	Fixed frequency Bekesy audiometry using Grason Stadler (model 1702) audiometer. Pre-exposure hearing levels measured at 125, 250,500,lk,1.5k,2k,3k,	Amount of TTS following steady state noise were larger than those from any intermittent exposure Awosg the intermittent conditions,	Results imply that the equal energy rule aay provide an adequate index for the assessment of hazards to hearing from steady state 4	

1	2	3	4	5	6	7	8
	index of potential hazards to hearing.		varying noises. Steady state noise-) 96dHA InteMiittent noise-) 99 i 45 dBi.Varying noise-)98 *i* 93 dBA, Exposed to 128 minutes.	4k,6k and 8kHz. Post-exposure hearing levels Measured at 1k 1.5k,2k,3k,4k,(k & 8 kHz.	amounts of final TTS: were a logarithmic function of the intermittency period. Equal aiounts of ITS were obtained follow-ing the steady state and the four varying noise exposures.	varying noises but not from interiit-tent exposures. Current principles of noise dosimetry ignore the paramet-ers of interiittent exposures that de-teraine their poten-tial danger to hear-ing.	
Robert, J.K., (1969)	To relate the ayap-tons and findings in a group of patients who were exposed, without ear protect-ion, to high inten-sity impulse noise for a short period of time.	14 sale subj-ects in age range 19-34 yrs, with a mean of 24.7 yrs	Exposed to fireares of 146-159 dB.	Pure tone audioietry at 500,1000,2000,3000 4000 and 6000Hz.	Pre-exposure thresho-lds -.Average hearing level in the right ear was -ldB *k* 2dB in the left ear. Post-exposure:Average loss of 12 dB was found in the right ear and 32dl in the left ear. Periodic testing for alaost ten weeks post -exposure revealed no iiproveient, indicat-ing that these iapai-reients were perna-nent.	Dissimilar loss is hearing, is because 13 of the 14 pati-ents shot shoulder weapons and all were right handed. The proper position for firing a shoulder weapon needs turn-ing the head. There-fore the left ear is tore directly in line with the noise source for & right handed shooter.	
Robert, C.F., (1976)	To consider further possible differences in auditor; function between noise exposed and norial listeners not apparent from basic test battery.	32 tales (IS noraals, 16-NIHL) in the age range 18-20yrs.	16 subjects exposed to noise daily over periods from 12-24 months.	l)BekesyFixed-Frequency Audioietry with Grason -Stadler lekesy audio-meter Model E-800-4. frequencies tested; 500Hz,U,2k & 4kBz. 2) SISI test at 2kHz using -Beltone 15C 3) Speech tests using Grason-Stadler Model	Fixed-frequency Bekesy audioietry: At 2kHz,twelve of the noise exposed sub-jects demonstrated separation of 5dB or more between pulsed & continuous tone tracings. SISI test: Score for	Tests of basic audio-letric battery lay not indicate the full extent of auditory dysfunction related to noise induced hearing loss. Tests of adaptation and discrimination of speech under adverse	

i	2	3		5	6	7	8
				161.	noise exposed subj- ects ranged from 0- 45%, i, for normal listeners, ranged between 0-60%. Speech discrimination tests; Mean scores for PAL PE-50 test me 62.88% & 69% for noise exposed & normals respectively. Mean scores for ¥-22 word lists Here 49.25% and 58.13% for noise exposed subje- cts & noraal listen- ers respectively. Mean scores for H-22 word lists Kith competing "Cocktail party" noise were 56.75% & 75.38% for noise exposed and normal listeners respec- tively.	listening conditions lay reflect the auditory changes more accurately.	
Roger, P.H., Donald, H., Syracuse., (1974)	To study the integrity of the organ of corti after exposure to high intensity impulse noise.	15 monoaural chinchillas, Imsec	Exposed to 50 impul- ses at 3 levels, 166, 161 & 155dB peak SPL having A-duration.	Auditory evoked res- ponse at 250,500,1000 2000,4000 and lOOOHz.	-For the t«o higher intensity groups the total number of miss- ing OBC varied over a wide range from a virtually normal hair cell population to approximately 4000 OHC missing. IBC losses varied from approximately 4 to 300 missing. -All animals exposed to 155 dB peak SPL	The reason for the large histological variability is the failure of the con- ductive mecchanism.	The results of auditory evoked response testing is not mentioned.

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					noise had almost identical lesioas centered at 9-12 as from the appex in-volving loss from 1,100 to 2,400HC. 40-140IBC were missing.		

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Roger, P.H., Willim, i.A. Keng, D.B., Sheau-Fang, L. Robert, I.D., (1993)	To determine whether any difference exists between the trauma produced by impulsive and gaussian noise exposures to loderate levels.	30 monoaural chinchillas divided into 3 groups.	Exposed to noise for 5 days (24 hr/day). Noise I-) Gaussian Noise II-> lon-gaussian Kith 114dB peak SPL. loise III - Pure iipact exposure with 117 dB peak SPL.	AHP threshold procedure Frequency:0.S - 16 kHz and 11.2 kHz. Thresholds were measu-red daily at 0.5, 2 and (kHz. After 5 day exposure was coaplete, thresholds at 0.5, 2 and 8 kHz were measured immediately. 30 days after exposure, final audiograms were constructed. Histological analysis:- Right auditory bulla removed and opened widely at 30-40 days after exposure.	Pre-exposure thresh-old differences among groups at any test frequency were relatively stall and never exceeded lOdB. Lover asymptotic threshold shift seen at 0.5 kHz for Noise I exposure. PTS = Clear differ-ences are seen at 4kHz between noise III group and the other 2 groups. PTS across groups was similar at 0.5, 1 and 2 kHz. Gaussian noise exposure produced least PTS. loise II exposure resulted in tore PTS than the gaussian exposure at 11.2 kHz. There was no significant differ-ence in the total sensory cell loss across the 3 groups, but thre were sign-ificant differences in the distribution of sensory cell loss across frequency.	The results show that, a purely impulse soise can producer significa-ntly more PTS at high test frequencies than an equivalent gaussian noise. Secondly, when the noise consists of a complex combination of impacts and cont-inuous noise in which the bandwidth of the iipacts is United, there is a large statistically signi-ficant differences between the B=3 and B-27 groups in the IHC loss in the 4kHz-octave - band length of the cochlea.	Pre-exposu-re i post-exposure thresholds have not been mentioned, so the amouot of threshold shift cannot be specified. The level of Gaussian noise is also not mentioned. No information regarding high frequency thresholds. More information regarding high frequency should have been given since noise is supposed to cause more hearing loss at high frequencies

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Sallustic, Y., et al., (1998)	To better understand the differences in hearing function in workers exposed to the same noise conditions.	180 sale subjects in the age range 21-63 yrs with a mean age of 44.9 yrs divided into 3 groups.	Grouph with 43 subjects with Lepd < 80dBA. (control group). Group A with 52 subjects with Lepd 80-85 dBA. Group B with 85 subjects with Lepd 86-90dBA with a hearing loss at 4kHz.	Tonal audiometry at 0.25-9 kBz and high frequencies at 9-llkBz. Speech audioietry. Tyapanometry and Seflexametry. TI Frequency selectivity. OAE. Interaural signal phase relationship.	Bearing impaired subjects had the worst overall cochlear performance, however also the normal hearing workers exposed to hazardous noise have worse performance than subgroup I, relatively to high frequency thresholds; frequency resolution; TEOAE's; DPOAE's; stapedial acoustic reflex dynamic parameters.	The results concerning the correlations between hearing impairement at 4 kHz and Lepd, age and seniority are consistent with international literature demonstrating that the percentage of subjects affected with HIBL progressively, although not significantly increases with Lepd (Kryter et al., 1966; Passchier-Veraeer 1973; Hard, 1979). In ears affected with IIBL the recruitment phenomenon, is present only for frequencies with hearing loss (Findlay, 1976; Carvellera et al., 1983).	
Salvi, R,J., Chen, L., Trautwein, P., Powers, I., Shern, H., (199!)	To study the recovery of function in the avian auditory system as the hair cells and supporting cells regenerate.	Chickens of > 12 weeks of age.	Exposed to 525Hz puretone presented at 120 dBSPL for 48 hours.	Behavioural,anatomical i electrophysiological measures.	Immediately after the exposure, the behavioural thresholds were elevated by 30-40dB & auditory TI was greatly reduced. Both measures recovered fully by 28 days. Tone-on-tone Basking patterns recovered to normal. The thresholds	The results show that there can be substantial i almost complete recovery of function in birds when the hair cells and tectorial membrane degenerate. Birds, like wassals, can develop permanent hearing	

1	2	3	4	5	6	7	8
					of single cochlear ganglion neurons were elevated lore than 30dB, tuning curves were broader. Two tone rate suppression (TIBS) boundary slopes were shallower and spontaneous activity was reduced. Threshold and spontaneous discharge rate recovered fully after exposure. Tuning and TTFS also recovered in most neurons. Sons units with characteristic frequencies near the exposure frequency shoved abnormal tuning and TTES suppression. Haircells & tectorial membrane were damaged in a cresent shaped patch along the abneural edge of the basilar papilla. TI = Temporal Integration.	deficits when the sound exposures are intense enough to destroy the supporting cells (cousillas & Rebillard, 1985).	
Sandra, L,M., Donald, H., Antonio, Q., (1997)	To evaluate the chinchilla as a model for EH and to begin to describe the parametric relationship between hearing loss and EM.	16 normal subjects. Expt I --> 4 Expt II --> 12	Octave band noise centered at 0.5 kHz at 90dBSPL for 6br/ day for 10 days.	Evoked potential recording: Frequency - 0.5 162kHz Hasker -> HBN with center frequency of 3kHz. EM -> Masked threshold -quiet threshold. (EM - Remote Masking	Expt-I: Threshold & rate of growth of RM-. Normal hearing chinchillas exhibit RH at masker levels of 58dB *i* above & the pattern of EM is essentially the sane as that seen in	Reduction in EM as a result of hearing loss could contribute to difficulty in understanding speech in the presence of noise. In the healthy cochlea, EH could serve to supp-	Should have tested the high frequencies to check whether this low frequency noise

1	234			5	6	7	8
				EM = Effective Masking)	normal hearing hUB-ans. Expt II: Eolation between TTS i II: Low frequency noise exposure produced significant TTSs at all three frequencies.	ress perception of low frequency noise coBponents in the presence of higher frequency speech components. Loss or reduction of RM with hearing loss could increase the perceptual salience of low frequency background noise.	exposure caused high frequency loss or sot.
Shalini, A., Richard, J,S., Sanuel, S., Saunders., Don, B., (1987)	To determine if the tine course of the evoked response "forward masking" pattern would be altered by a tone exposure that produced a significant TTS & little or no PTS.	10 monoaural Chinchillas weighing 400-800 g»s.	2kHz pure tone of 85dBSPL presented from 5-8 days.	Evoked response thresholds measured by forward masking data for frequencies from 0.5-16kBx (in quiet). 3 threshold measurements each (Pre-4 Post-exposure). Forward masking - 0.5, 2, 4 and 8 kHz.	Pre-exposure-> Normal hearing. Post-exposure: Increase in threshold at mid frequencies. 4kHz=35dB, 2kHz*25dB 3kHz=18dB, lSkHz-5dB 0.5 kHz-Normal. The exposure altered the time course of the evoked response forward masking data. Time constants fitting the forward Basking data increased by upto a factor of 3 at the frequency with the greatest loss, hut remained within normal limits at low frequencies where hearing was normal. The increase in forward Basking time constants became most noticaiable once the hearing loss exceeded by 25dB.	The main finding was that the time constant of the evoked response forward Basking pattern increased at frequencies with temporary hearing loss, but not at frequencies with normal hearing. Gorga and Abbas (1981) indicated that there was no change in the action potential forward masking time constants, but did report a change in the growth of masking.	

1	2	3	4	5	6	7	8
Shalini. A., Richard J.S.., Sawuek S.S., Michael, A.G., (1989)	To explore the possibility of central changes, the evoked response forward tasking functions in the inferior colliculus of the chinchilla before and after inducing a noise induced PTS.	10 normal chinchillas neighing 400-BOOg.	Hearing loss induced with a 2kHz puretone having an SPL of 10SdB. Duration of exposure was 5 days.	Evoked response forward-masking fuDctions. Frequencies-) 0.5-16kHz at octave intervals.	Effect of hearing loss on the time course of forward tasking was most pronounced once the hearing loss exceeded 20-25dB. The physiological changes in evoked response forward tasking functions appear to para-1lel those observed psychophysically in hunan listeners.	The results of the present study indicate that the time course of the evoked-response forward masking function can he altered by a n oise induced PTS. The tendency of the evoked response tise constant to increase with hearing loss is consistent with the results of several psychophysical studies such as the study done by Feston and Ploap (1983).	Since the post exposure means reseants were taken after 30 days of exposure there light have improvement in the thresholds.
Shannon, s,c., Jiri, P Stephen H.P., Travis A. Travis (1989)	To investigate the effects of long-tera exposure to high doses of aspirin and high intensity noise.	38 rats neighing 100-400gns. Gpl- Control-BSrats GpII-7rats GpIIHrats GpIV-7rats GpV-Brats.	Aspirin «as given to group II, II, ¥ for 18 days. Group III, IV & V were exposed to noise 16hrs/day for 13days 110 dBSPL filtered white noise.	Baseline hearing thresholds taken. 24 hrs of 3 weeks after noise exposure Auditory brain stem evoked responses, Threshold, latencies and aaplitude were recorded. White noise centered around 8kHz were used, Since testing in a free field with pure tone generates standing waves, narrow band pips filtered white noise were used .	Significant differences in PTS and hair cell loss between all noise .exposed animals & non noise exposed animals were found. Greater amount of hair cell loss was found in group V when coapared to groups III & VI. Group V also proved to be fatal for 6 of 15 of these aniaals & caused weight loss in the survivors.	Results indicate that a combination of aspirin at high doses and noise will produced significant hair cell losses in the rat ear that are greater than losses from the same aaount of aspirin or noise alone. The difference in hair cell loss between the 8-day per 200 mg and 12-day per 200 mg of aspirin per noise suggest the possibility that critical level of salicylates may be	Frequencies tested are not lentioned. Latencies and asplitudes were recorded, however no information of the sane is mentioned in terms of results.

1	2	3	4	5	6	7	8
						required in cochlear tissues to produce penanent bair cell daiage and concentr-ations below this level have no effect.	
Sinex, D.G., Clark, W,W., Bohne, B.A., (1987)	To study the effects of rest on physiolo-gical measures of auditory sensitivity following exposure to noise.	4 chinchillas	Chinchillas were exposed to 500 Hz octave band of noise at 95dBSPL for 15min/hr for 4 or 40 days.	Action potential (AF) responses at 1/2 octave steps between 0.5-11.3 kHz Here measured	AF thresholds were elevated by about 40dB on day 4, betw-een 0.5kHz and 8kHz. On day 40, AF thre-sholds at the sate frequencies were lower by 10-25dB. Tuning curves leas-ured on day 40 were sore normal in appe-arance.	The results of these leasurements confirmed that the initial behav-ioural threshold shift and recovery during the interrittent exposure can be attributed to changes in the sensit-ivity of the peripheral auditory system	
Sirkka, M., Jukka, V., (1980)	To compare hearing thresholds of 4 groups. 3 working in impulse noise from 3-10 yrs and one in a draughtmans office	30 divided into 3 groups Mean age: Gpl-24.6yrs GpII-28.3yrs GpIII-30.1yrs Control Gp - 23.8yrs. (Gp-Group)	GpI-> 3-4 yrs. GpII->S-6 yrs GpIII->7-10yrs Hassering-) 130-140 dB(A) Pneuaatic chisels-) 120-125dB(A) Grinding-) 115-120 dB(A).	Pure tone audiometry. Frequencies tested-) 1, 2, 4, & and 8 kHz. Tested 10 minutes after the exposure, for 3 times in a day.	Morning hearing thresholds: Gp I had higher hearing thre-sholds at l-2kHz, Gp II had higher thr-esbolds at 2-8 kHz & Gp III had elevated thresholds at (kHz. compared to the control gp. Midday hearing thresholds: Exposure groups had higher thresholds than control gp. Gp II at 1kHz t 4-8khz, Gp III at l-8kHz. Afternoon hearing thresholds: Gp I & II had higher thresholds	Results shot that longer the exposure time in impulse noise, higher were the threshold shifts.	The number of subjects in the control group has not been Mentioned. The thresholds at each frequency has not been Mentioned. Has not been aentioned as to which group has been exposed to what noise.

1	2	3	4	5	6	7	8
					at 2kHz. Gpl had a significant threshold shift at 4kHz when compared to the control group.		
Sohner, H., Pratt, R (1975)	To measure the behavioural decrease is auditory sensitivity and neural decrease simultaneously in the same subjects.	10 normal adults.	Exposed to 90dBSPL white noise for 30min.	Electrocochleographic recordings aere made in response to SOdBSL clicks. Recordings were done pre-exposure, after 15min of exposure and finally after 30min of exposure.	Exposure to white noise produced temporary threshold shifts. The largest decrement (amplitude decrease *k* latency increase) was seen in the response of the auditory nerve. Large intersubject variability was seen in the effects of the noise exposure on response amplitude, latency *k* recovery rates.	This is the first electrophysiological study of ITS on unanaesthetized massals in general and the first such study on human subjects. It is clear that the TTS observed behaviourally is truly accoapined by a neural decrement expressed as an H1 aaplitude decrease and latency increase. This decrease can be due to a decrease in the the number of fibers activated and/or to a decrea'se in the synchrony of firing (Benitez et al., 1972).	
Stephen, A.F., et al., (1981)	To coapare the effects of steady state noise versus ispulsive noise upon human hearing sensitivity from 8000 to 20000 Hz.	36 subjects with age range 20-29 yrs.	14 subjects exposed to ispulsive noise eg:gunfire, grenade:S etc. 22 subjects were exposed to steady state noise such as flight line duty, aircraft in flight duty, etc.	FTA (AC and EC) at frequencies 250, 500, 1000, 2000, 3000, 4000, 6000 t 8000 Hz, High frequency tests done at frequencies 8000-20000 Hz at 1000 Hz intervals.	Threshold shifts (TS) were prominent for the steady state noise exposed subjects froa 13-20kHz. Mean thresholds froa 8 through 12kHz were maximally 20dB poorer than a sample of young aduld normals.Audiometric configurations for this group were smooth	Conventional audiometry from 250-8000 Hz in young adults provides the impression of relatively normal hearing sensitivity in a potentially abnormal ear due to limited frequency range tested. Measurement of hearing sensit-	

1	2	3	4	5	6	7	6
					and syametrical above 8kHz. For the impulsive noise exposed group, substantial shifts is sensitvity were seen from 2 to 20 kHz & the high frequency audiometric configurations were often jagged and/or asymmetrical.	ivity above 8000Hz holds promise for better detection, description, and differentiation of NIBL.	
Swanson, S.J., Dengerink,H,A., Kondrick, P., Killer, C.L., (1987)	To replicate t extend the findings of Lindgren and Axelsson of greater TTS after acoustic stimuli the listener finds aversive.	20 normal males.	Music & noise exposure of 106dB via earphones for 10 minutes.	Audiometric screening procedures ->Pure tones, tympanograms, ARTs. Equipment: Industrial Acoustics Model 1200A. Teledyze Acoustic Impedance meter TA-4D. Dexlar Bekesy audiometer 120 to assess thresholds at 416kHz-	Subjects tho liked the music exhibited less TTS following music than noise. They also exhibited less TTS in music than the subjects «ho disliked music. Those who disliked music evidenced greater magnitude of TTS in music than noise.	The findings that persons aho liked music selection evidenced less TTS at 6kHz after ausic than after noise of equal energy replicated the results reported by Lindgren *i* Axelsson, Results indicate that the TTS differences found in music & noise may be a function of recovery time.	Age of the subjects is not given. No results of tyspanograms 4 ARTs are Mentioned.
Syka, J., Popelar, J., (1980)	To estimate auditory threshold shifts in 3 guinea pigs after a 5 day exposure to third octave band noise centered at 2kHz.	3 normal guinea pigs in 4-24mth age :range.	Exposed to third octave band inoise centered at 2kHz at 100 dBSPL for 5 days.	Auditory thresholds assessed in each animal several times before the noise exposure at frequency 125Hz-16kBz (8 frequencies).	Pre-exposnre-> Maximum sensitivity was at 8kHz. During exposure: Thresholds me measured at intervals of several hrs at frequency 0.5, 2 t 4 kHz. In some cases thresholds at all frequency were measured. At	Threshold shifts produced by prolonged exposured to noise in guinea pigs are coaparable with the data obtained is chinchillas,. The atln difference between the guinea [pig and chinchilla m found in the recovery	

1	2	3	4	5	6	7	8
					5kHz the threshold increased rapidly to 40dB on the average after 6 hr exposure. Total shift was 45dB by the 5th day. At 2kHz the threshold increased less markedly and more slowly. Threshold shift at 0.5 kHz were relatively small. Recovery from threshold shifts evoked by 5 days noise exposure was slow. 50 days after the exposure the thresholds at 4kHz were shifted against pre-exposure levels by about 35dB. This can be considered as PTS.	period. The influence of noise exposure oni the steepness of psy-chophysical functions at higher frequencies may be related to lou-dness recruitaent, a phenooenon which occurs in sensory deafness in man.	
Szasto, C., Ionescu, H., (1983).	To study the influence of age & sex on hearing threshold levels in workers exposed to different intensity levels of occupational noise.	1030 normal subjects divided into two groups. Group I: 240 females-30.4 yrs10.6 262 »aies-29.6yrs+9.7. Group II 22% females-30yrs+9.8 300 males-30.5yrs+10.1	Group I-Exposed to an equivalent level of 83dB(A). Group II-Exposed to an equivalent level of 98dB(A).	Audiometric tests using HA-30 clinical audio-meter.	Large differences exist between the sale & female popul-ations exposed to a constant sound level of 9BdE(A) as well as between the 2 groups of sales. The difference between the rate of change in HTL exposed to 98 and 83dB(A) increases with the duration of exposure in males.	The results are in concordance with those reported by Pinter (1975) where Pinter took into consideration the effects of socioa-cusis and sex in expressing the HIHL. Industrial noise exposed females are more susceptible to high frequency hearing loss at lower intensities.	Age group and the duration of noise exposure has not been specified. The .frequencies tested also has not been mentioned. Not Mentioned whether the

1	2	3	4	5	6	7	8
					Related to age factor these differences decreases Kith age for men and increases for women. The HTL's obtained in the group exposed to 98 and 83dB(A) Mere compared to those of the non-exposed group of Royster and Thomas (1979). The highest difference was found in males exposed to 98 dE(A).		theshold shift is more at high frequencies or at low frequencies.

1	2	3	4	5	6	7	8
Tapio, P., (1991)	To analyse the magnitude of the TTS in both ears and the correlation between the ears at 4kHz.	28 normal subjects (10 sales and 18 females) in the age range of 17-29 yrs and a mean age fo 21.9yrs.	Hoise generated through Nadsen QB70 audiometer. Ssales I 7females-> SSdBA BB1 for 4hrs Smales & llfeaales-> 91dBA BBI for 15 hrs.	Audiometry using Madsen OB822 (calibrated according to ISO-389 std). Frequency-) 4kHz. Exposure was interrupted after every 30 sin One ear tested for every interruption. Pre-exposure thresholds Here taken 3 tines for both ears and averaged. 12hrs after cessation, 3 readings me again taken and averaged.	91dBA-> TTS us greater in the left ear than in the right ear. 88dEA-> Threshold shift was roughly half that produced by 9ldBA. Left ear produced more threshold shift. Pearson's correlation coefficient between TTS values for left and right ear after 5.S hrs of exposure was 8.57 After 7.5 hrs of exposure the correlation coefficient was 0.51.	Shooting noise is known to affect the left ear lore than the right, because when a right handed person shoots with a rifle, the blast is directed sore to the left ear.	Not mentioned regarding the amount of TTS. Not mentioned whether the threshold shift returned back to pre-exposure level 12 hrs after cessation.
Tapio, P., (1991)	Pre-exposure hearing threshold *i* temporary threshold shift at 4kHz frequency.	28 normals (1! females i 10 sales) in the age range 17-29 yrs. i mean age of 21.9 yrs.	16 subjects-)exposed to BBH of 9idBA. 12 subjects-) exposed to noise of SSdBA. Noise was reversed after every 30 sin i.e. initially the noise was given to the left ear 4 after 30 min given to the right ear.	4kHzz hearing threshold was tested within 1 sin of interrupting the exposure. TTS-) Post-exposure thresholds-pre-exposure thresholds. Hearing threshold tested again 12 hrs after cessation of the exposure. Interpolation procedure values analysed by microcomputer using SAS software.	4kfiz thresholds for both ears before, during 12hrs after exposure: 9ldBA noise -) Left ear worse than right after 3 and 5.5hrs of exposure. Ho significant difference before i 12hrs after words. 88dBA noise-) Left ear was worse than right during 1st hrs of exposure. TTS as a function of pre-exposure hearing threshold: A negative correlation was	Negative correlation between the pre-exposure hearing threshold i the TTS indicate that this effec concerns not only true pre-exposure hearing loss or sisulated hearing loss but also pre exposure hearing thresholds within normal limits. There was a difference between ears concerning the correlation of the pre-exposure hearing threshold level with	

1	2	3	4	5	6	7	8
					found between the pre-exposure hearing threshold i ITS in the left ear aiong subjects exposed to 91dBA noise.	ITS.	
Tetsuo, M., Michael,A.S. Dixon, K.V., Michael . Jeffrey, J., (1985)	To examine the effect on auditory function of a high cholesterol diet maintained for upto one year in the chinchilla & the possible increased susceptibility to noise exposure of hyperhpidemic animals.	38 chinchillas	GroupI->I=20, 1% cholesterol diet for & mths. GroupII-)H=9, lormal diet. GroupIIN=9, loise exposure controls. Group I & III exposed to 2 - octave bandpass noise (700-2800 Hz, lOSdB, 220 min).	Auditory brain stem response audiometry at frequencies 4, 8, 12, 16 kHz. Measurements obtained before & 1, 3,5&6 aths after initiation of diet. Compound Action Potential measurements obtained one mth. post-trauna.	A significant reduction in ABR was seen at 5 mths on diet. One animal died approximately 2 hrs after noise exposure & another died 2 weeks following exposure. One month following noise'exposure, the cholesterol fed animals exhibited a greater ABE latency shift at low intensities and an elevated action potential threshold at higher frequencies.	The results implicate 2 major hypothesis a) Diet induced hyperlipidemia can effect cochlear function. b) Hyperlipidemia can render the cochlea more susceptible to noise exposure. Hyperlipidemic state can lead to cardiovascular insufficiency & profound effects on peripheral circulation. Hence it is not surprising that the cochlea, in such an environment, might be more susceptible to trauma such as noise.	
Thiery, L., Meyer-Bisch, C (1981)	A cross-sectional epidesiological survey conducted in a carbody workshop, where the average noise levels range from 87-90dB(A).	234 studied population. 2 reference population. Studied population: Class I-> age-29.9 yrs. Exposure dura-	Reference population: One exposed to occupational noise level not tore than 80dB(A). Other exposed to continuous industrial noise of 95dB(A).	Audiometric test (Philips type A07B). Audiometer calibrated in accordance with ISO 389-1979. Frequency:500-8000 Hz at octave intervals.	Results reveal significant hearing loss after 9 yrs of exposure, greater than that from quasisteady noise exposure with the same equivalent continuous A-wtd SPL.	The risk of hearing handicap observed in this population is higher than that given in various epideniological studies concerning exposure to quasisteady	

1	2	3	4	5	6	7	8
		tion-> 9.2 yrs Class II-> age- 34.6 yrs. Exposure dura- tion -> 14.1 yrs Class III-> age- 39.5 yrs. Exposure dura- tion-) 17.9yrs.			Studied population had hearing loss inc- rease of 6dB at lot frequency in compar- ison with the non-ex- posed population. 3-SkHz -> Increase of 15dB for 50% of popu- lation & exceeds 20dB for 10% of popula- tion. Ho differnce over lOdB in hearing threshold levels exc- epts at 152 kHz in comparison with those exposed to 95dB(A) noise.	noise of levels close to 90dB(A) i those estimated using ISO 1999-1987. Equal energy crit- erion itself is ins- ufficient to quantify the risk of hearing loss in cases where the sound produced is partly impulsive.	
Ulf, E., lai, P., Alvar, S., (1990).	To study age related changes in hearing in a representative sample of 70 year old and to eval= uate the effect of protracted occupational noise exposure on the hearing at old age.	1148(FOl) of 70, 75 & 79yrs- 1281(F06) of 70 yrs. F01-> first cohort F06-) Second cohort.	Group l->Not exposed tp noise. Group 2 - Exposed to noise from l-15yrs. Group 3-Exposed to noise for 15 yrs or more.	Pure tone audiometry.	70 yr old ten exposed to occupational noise had 10-15dB poorer hearing in the high frequency range than non-exposed ten. The difference in hearing acuity decreased with increasing age. In women there were no significant differe- nces in hearing sensitivity between those exposed to noise and those not exposed to noise. Hen not exp- osed to noise had 10-15dB poorer hearing at 4kHz coapared with women of the saae age also not exposed to noise.	Exposure to noise is a very important extraneous noxious factor invovled in hearing loss in old age (Glorig & Mixon, 1960). In this study no difference between the right & left ears were observed in contrast to other studies in which the left ear had a lore pronounced hearing loss than the right one (Baughn 1966; Pudin, Eosenhall & Svardsudd, 1988).	BC thresh- olds should have been checked to see the type of loss. Pre- exposure audiograms would have given more information.

1	2	3	4	5	6	7	8
Virich, B,F. Marilyn,L,P. (1974)	To investigate the teaporary and any possible permanent EIHL in a group of teenagers actually exposed to long hours of highly amplified live rock-and-roll music over a series of eight weekly discotheque sessions.	14 (4 boys & 10 girls) subjects ranging in age froa 13-17yrs.	Exposed to & weekly sessions of rock-and-roll music with an average SPL of 110dB-1l5dB.	Pure tone audiometry at 250, 500, 1000, 2000, 4000 & 8000Iz.	Significant TTS were found in all subjects, especially in the high frequencies. All subjects deaonstrated the most TTS at 4000Hz with 2000Hz *k* 8000Hz affected to a lesser degree.Hearing sensitivity recovered between the repeated exposures, *k* a 5-month follow-up study found that hearing in all subjects except one returned to its initial pre-exposure level. Exposure had differential effects on the two ears at the same test frequencies.	Results of this study closely agree with other reports in literature on TTS due to exposure to rock-and-roll. There was no way to deteriine whether the permanent decrease in hearing sensitivity found at follow-up in one of the subjects was due to repeated rock-and-roll exposures.	Duration of exposure per session is not given.
fillia,M.C. Clark,S,C, David, B.M., William,C.S. (1974)	To determine hearing sensitivity i IIHL in the chinchilla using a positive reinforcement procedure.	4 chinchillas (2 males & *2* females) where 3 subjects were one & 1 1/2 yrs old and one was ten yrs old.	2 animals were exposed to 123dBSPL band of noise (710-2800 Mx) for 15 ain.	Behavioural measurement (positive-reinforcement procedure. Cochleogram.	Both animals showed a considerable PTS that agreed closely with the degree of change seen in the cochlea. The maximum threshold shift was 94dB at 2.8kHz and maximum recovery,21 dB occurred at 4kBz for one animal. The other animal showed maximum threshold shift of 92dB at 2kHz and maximum recovery of 49dB at 4kHz. The outer hair cells were missing depending	This behavioural measure is longer, however this disadvantage is outweighed by the increase in objectivity that the automated testing feature affords. In this procedure the chinchilla does exhibit a considerable PTS froa a 15min 123dB exposure that agrees closely with the observed trauto in the inner ear. Contrary to previous findings, this rela-	Should have taken all the subjects of the sue age. Frequencies tested are not neationed.

1	2	3	4	5	6	7	8
					on the degree of hearing loss.	tion in the chinchilla is consistent with those observed in other massals.	
Villias,F.R. Robert, F.L. Ellen, S.S., (1971)	To clarify the effects of exposure to intermittent & continuous rock and-roll music on hearing threshold level..	20 normal females in the age range of ll.llyrs-22.6 yra with a mean age of 20.lOyra.	Exposed to rock-and-roll music played continuously for 60 min and other recording of the same music with lain of discotheque ambient noise spliced between each 3-min musical selection.	Bekesy audiometry at 1000, 2000, 3000, 4000, 6000 *k* 8OOOHz prior to *k* 4 times following each exposure.	TTS was greater for the continuous exposure, recovery occurred more rapidly. TTS was greatest in the frequency range from 3000-6000Hz the largest shift occurred at 4000Hz. Continuous music resulted in greater shifts in threshold than intermittent music. Recovery tine was similar under both conditions.	When comparing the present with previous studies concerning rock-and-roll music, the following two observations are made. While the amount of TTS is quite variable among individual subjects, the mean TTS appears fairly constant. When coaparing TTS resulting from intermittent exposure, the mean levels are consistently below 25dB.	
Tates, T.J., Ransey, D.J. Holland,I.J. (1976)	to cospare the damage risk of 85 and 90dBA of white noise for equivalent full day exposures,	12 nortal (6 males, & females) college age subjects.	Group l-)3males 4 3 females exposed to 90dBA of white noise-Group 2->3males & 3 females exposed to 85dBA of white noise-Exposed to white noise for equivalent half t full day.	Pure tone audiometry (Bekesy type) using Grason-Stadler, Type E-800 audiometer. Frequencies tested-) 1, 2, 3, 4, 6 t 8kHz.	Potential daiage risk, that is, hazardous effect of 90dBA is greater than 85dBA of noise for equivalent full day exposures. Damage risk of a full day exposure to 8SdBA is equivalent to that of a half day exposure to SOdBA of noise.	A comparison between the statistical results of TTSt (TTS measured after the various time intervals, t) & TTS: data indicated virtually no difference between the two measures for deteraining the damage risk of noise exposure. Therefore TTSt was as effective as TTS: for estimating	

1	2	3	4	5	6	7	8
						the damage risk of noise exposure.	
Ylikoski.J. (1987)	To analyse the relationship between puretone audiometry findings k etiological factors in a large group of Finnish conscripts who had suffered acute hearing loss induced by firearm shooting.	361 subjects with the average age of 20 yrs.	Suffered acute acoustic trauma during their military service.	Pure tone audiometry using clinical audiometer calibrated according to ISO 389. Frequencies tested were 0.2S-8kHz at octave and mid ocatave intervals.	In more than 751 of the ears the hearing loss was found in the high frequency region (above 2kHz). In 25%, the speech frequency range was also affected. The main threshold shift started at 1kHz in at, at 2kHz in 49%, at 4kHz in 19% & at 6kHz in 6% of the ears. Impulse noise from large calibre weapons & explosions caused low frequency hearing loss slightly more often than small arms fire.	The great majority of the audiometric shapes of the present conscripts (abrupt threshold shift from 2kHz) were similar to the audiograms seen commonly in advanced NIHL. Thus, in these cases, a single exposure to shot impulses had often caused NIHL of a degree which in connection with steady state noise usually takes years to develop.	Pre-exposure audiograms or the medical details should have been taken of those ears who had hearing loss even at low frequencies to check for other causes of loss. The duration of exposure is not mentioned.
Tokoyasa, T. Osako, S., Taaatoto, I. (1974).	To investigate the seperate effects of noise k of vibration, k their combined effect, on huaan hearing.	8 normal sale subjects with the age range 27-35yrs.	Exposed to vibration of 300CPM (5Bz) k 1000 CFM (16.7HI), to broad band noise of 82dBSL t to both.	Bekesy audioaetry at 4kHz.	There was no significant change in threshold sensitivity after exposure to vibration alone. Exposure to vibration and noise simultaneously caused greater TTS & longer recovery time than exposure to noise alone. TTS produced by exposure to noise alone was a mean rise in threshold of 5dB whereas, the rise in	Effects of combined noise k vibration might be the results of some disturbances of physiological homeostasis or possible mechanical interactions with its blood supply.	Effects of vibration on the auditory organ Bay vary with the experimental condition. Hence many more studies need to be done before the effects can be elucidated.

1	2	3	4	5	6	7	8
					threshold us 12dB for simultaneous exposure to vibration and noise.		
Zurek, P.M. Clark, 1,1. (1981)	The study was done to search for acoustic emissions in the ears of chinchillas, motivated by the opportunities that would be afforded by instances of OAE's in anisals and encouraged by high incidence of OAE's in humans.	23 chinchi-lias	17 out of 23 chinch-illas were exposed to intense noise.	Narrov band otoacoustic emissions at frequenc-ies 0.5 - 8.5iHz.	Acoustic search in 21 ears of 17 chinc-hillas exposed to a variety of high intensity sounds revealed two instan-ces of a spontaneous & continuous narrow-band acoustic signal eaanating from the ear. These signals, found in the 4-7kHz region,after expos-ure to an octave hand of noise centered at 0.5kHz, could be suppressed by external tones. The frequency selec-tivity & time course of the suppression effect suggest that these OAE's originate from a vibratory source in the cochlea.	The hypothesis of active lechanical assistance in normal cochlear functioning *k* another hypothesis of OAE's caused by particular damage to the organ of corti are not Mutually exclusive, the very existence of OAE's should not be consi-dered proof of the foraer proposition.	

SUMMARY

SUMMARY

The journal articles reviewed in this project attempted to provide a concise report about the literature available on audiological evaluation of NIHL. The articles reviewed are summarized and tabulated in the following manner.

Table I: Number of studies in different journals reviewed.

Journal	Number
J.A.S.A.	45
Acta Otolaryngology	17
Scand. Audiology	17
Audiology	10
Ear and Hearing	10
Archives Otoloaryngology	6
J.A.R	5
B.J.A.	4
Hearing Research	3
J.S.H.R.	3
J.S.H.D.	2
Hearing Journal	2
Audiology and Neurotology	1

Among the journals reviewed it was found that J.A.S.A. had the maximum number (36%) of articles on audiological findings in NIHLs and Audiology and neurotology journals had the least number (0.8%). More number of journal articles could have been reviewed through internet.

Table II: Different types of subjects in the articles reviewed:

A.	**ON HUMANS**	**NUMBER OF ARTICLES**
	Total number	73
	Normal humans	63
	Humans with NIHL	5
	Normals and NIHL	4
	Head injury and other diseases of the ear	1
B.	On Animals	Number of Articles
	Total Number	52
	Chinchillas: Normal	15
	Monoaural	13
	Rats	6
	Guinea Figs	5
	Monkeys: Normal	5
	Monoaural	1
	Cats	2
	Mongolian Gerbils	2
	Rabbits	1
	Albino + Pigmented pigs	1
	Chickens	1

(a) **More** number of humans **were tested compared** to animals. 58.4% of the studies used human subjects and 41.6% of the studies used animals as the subjects.

(b) Most of the studies were done by inducing hearing loss by exposing normal hearing subjects to noise rather than those who were already exposed to noise.

(c) Among humans, maximum number of studies were conducted on normal hearing subjects (86.30%) when compared to those with NIHL and lead injury and other diseases of the ear (1.37%).

(d) Among animals, maximum number of studies were conducted on chinchillas (53.84%) when compared to other animals. As seen in the table, 13 of the 28 chinchillas were surgically made monoaural by destroying one of their cochleae.

Table III: Audiological tests administered in the articles reviewed.

HUMANS		**ANIMALS**	
Tests administered	Numbers	Tests administered	Numbers
PTA	32	Behavioural Measurement	15
Bekesy Audiometry	16	ABR	15
PTA + Impedance audiometry	3	Cochlear Microphonics	4
ABR	2	ABR + Behavioural Measurement	3

PTA + Loudness Balance test	2	Electrocochleography	3
PTA + Impedance + Speech audiometry	2	OAE	3
OAE	1	Action Potential	3
OAE + PTA	1	OAE + evoked potentials	2
PTA + STAT + ART + BERA	1	ABR + Impedance audiometry	1
Bekesy audiometry + ART	1	ART	1
PTA + Speech audiometry + TDT+ SISI + Bekesy audiometry	1	Auditory evoked response audiometry + Tympanometry	1
		Electrophysiological measurement	1
PTA + LDL + Bekesy audiometry	1		
Bekesy audiometry + TOM	1		
Bekesy audiometry + SISI + Speech audiometry	1		
PTA + TOM	1		
Electrocochleography	1		
PTA + Balance test	1		
PTA + Intelligibility test + Bekesy audiometry	1		
Bekesy audiometry + Evoked response audiometry	1		
Frequency discrimination	1		
PTA + ABR + OAE + Impedance	1		
Tonal audiometry + Speech audiometry + TI + Impedance audiometry + Frequency selectivity + Interaural signal phase relationship + OAE	1		

(a) The most commonly used audio logical test was pure tone audiometry (43.24%) and Bekesy audiometry (21.62%) for human3, and behavioural measurement (29.41%) and ABR (29.41%) for animals.

(b) In 1960's the audiological tests used were PTA and Bekesy audiometry. In 1970s along with PTA and Bekesy audiometry, other tests such as speech audiometry, Impedance audiometry, ABR, Special tests, Behavioural measurement, Cochleogram and cochlear microphonics were also used. It was later in 1980s that OAE and balance test was brought into picture in the evaluation of NIHL. Measurement of TLS, Effective mas-Ring, Temporal integration, Frequency selectivity, Interaural phase relationship was later used in 1990s.

(c) In 1960s, studies were conducted on humans only and the authors studied TTS and recovery from TTS. From 1970s experiments were conducted on animals also. In 70s, TTS, recovery from TTS, PTS, type of recovery, effects of rock-and-roll music, snow-mobile engines, effects of noise and vibration, noise and other agents, adequacy of ABR in detecting NIHL, changes in acoustic reflex after exposure to noise, anatomical effects in inner ear were also studied. Comparison studies such as comparison of recovery in animals and humans, TTS and TLS were carried out. The purposes or main objectives of the studies done in 1980s were to establish risk limits for impulse noise, to search for OAE's in noise exposed ears, to compare the effects of steady state noise and impulse noise, to investigate the phenomenon of temporal integration, influence of age on NIHL, to study TTS, relationship between TTS and PTS, interaction of noise and vibration, interaction of noise and other solvents and also to study the inner ear pathology.

Finally, in 1990s more advanced studies were done where the purpose of study were as follows:

The authors studied, Age and TTS, Right-left correlation, TTS, PTS, Effects of noise and other agents on hearing, Histological changes, Application of frequency and time domain kurtosis, A comparison study of impact noise and continuous noise on hearing. Changes in TEOAE, DPOAE, TTS and TLS, Noise induced changes in central acoustic pathways, recovery functions in avian auditory system and conditioning and NIHL.

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APPENDIX

APPENDIX A: Acronyms used in the project

Acoustic reflex threshold (ART): The lowest intensity at which a stimulus can elicit the acoustic reflex.

Air Conduction (AC) threshold:

The measurement made with the air-conduction earphones of an audiometer that checks the hearing sensitivity of the entire auditory system through AC mode of hearing.

Asymptotic threshold shift (ATS):

Auditory thresholds increase upto a point following noise exposure, where further exposure to noise brings about no corresponding increase in threshold.

Auditory brainstem response (ABR):

The seven wavelets recorded by means of the electrodes that appear within 10 milliseconds after signal presentation.

Auditory evoked potentials (AEP):

The use of summing or averaging computers with EEG to measure the very small electrical responses to sound observed from the cochlea, brainstem and cortex.

Bone Conduction (BC) threshold:

The measurement made with the bone conduction vibrator of an audiometer that theoretically checks the hearing sensitivity of the inner ear and auditory structures medial to the inner ear through bone conduction mode of hearing.

Broad Band noise (BBN):

A sound in which energy is present over a wide range of frequencies. The energy percycle is equal and it is used for masking in speech audiometry.

Damage Risk Criteria (DRC):

Specifies the maximum level of noise to which an individual may be exposed for a given duration and length of time without the risk of acquiring hearing loss.

Distortion product otoacoustic emissions (DPOAE):

These are emitted by the inner ear in response to two simultaneously presented pure tones.

Ear protective devices (EPD's):

Devices wcVn by the individual that reduce the level of sound reaching the ears to protect them from damage.

Effective Masking (EM):

The minimum amount of noise required just to mask out a signal (under the same earphone) at a given hearing level (HL).

Example : 40dB-EM will just mask out a 40dB-HL signal.

Evoked potential (EP):

Electrical potential generated by brain wave activity in response to a stimulus - sound, for example.

Hearing threshold level (HTL):

The hearing level required to reach the threshold of an individual ear is the hearing threshold level for that ear.

Inner Hair Cells (IHC):

Sensory cells for hearing, arranged in a single row on the modiolar side of tunnel of corti in the inner ear.

Just noticeable difference (Jnd):

The smallest change in frequency or intensity which can be recognized.

(Lepd) Equivalent exposure level perday:

Equivalent exposure level per day values, calculated from the several noise conditions encountered during a workday.

Loudness equivalent quotient (Leq):

It is the level of a continuous A-weighted noise that would cause the same sound energy to be experienced in a given day as that resulting from the actual noise exposure.

LoudnesS discomfort level (LDL):

Sound pressure level at which speech becomes uncomfortably loud.

Low Pass Filter (LPF):

A low pass filter is a wave filter having a single transmission band extending upto some critical or cut-off frequency, not infinite.

Noise immission level (NIL):

NIL is the measure of total noise exposure that uniquely determines the NIPTS.

Noise induced hearing loss (NIHL):

It refers to slowly progressive inner ear hearing loss that results from exposure to continuous noise over a long period of time.

Noise induced permanent threshold shift (NIPTS):

The hearing loss produced by the effects of noise as a result of accumulation of noise exposure which are repeated on a daily basis over a period of many years.

Noise induced temporary threshold shift (NITTS):

Temporary sensorineural hearing loss, associated with exposure to intense noise.

Outer hair cells (OHC):

Sensory cells for hearing, arranged in three parallel rows on the strial side of the tunnel of corti in the inner ear.

Permanent threshold shift (PTS):

It refers to the hearing loss following noise exposure from which recovery is not possible.

Pure tone audiomotry (PTA):

A procedure for determining the thresholds of hearing, where, the pure tones at various frequencies are presented through earphones, bone vibrator and loud speakers.

Remote masking (RM):

Refers to the fact that a high frequency band of noise, provided, it is sufficiently intense, will elevate the audibility threshold for puretone of low frequency.

Speech recognition threshold (SRT):

The threshold of intelligibility of speech; the lowest hearing level at which 50 percent of the spondees presented are identified correctly.

Temporal integration (TI):

A time-intensity trading relationship in which intensity of a tone must be increased to obtain threshold when its duration falls below a critical minimum.

Temporary threshold shift (TTS):

It is a temporary elevation in the threshold of hearing following exposure to noise. The hearing functions then recover gradually.

Temporary Loudness shift (TLS):

Auditory fatigue measured by the reduction of loudness.

TTS_2: TTS measured after 2 minutes of quiet period (after noise exposure).

Threshold shift (TS):

A threshold shift is an increase in the threshold of audibility for an ear at a specified frequency expressed in decibels.

Threshold Octave Masking (TOM):

A test to determine the susceptibility of the subject to NIHL.

Eg: Introduce a 2kHz tone at threshold level. Then introduce to the same ear a 1kHz tone and find the intensity required to mask the 2kHz tone. This intensity in the TOM value for 2kHz. The 1kHz tone will be able to mask the 2kHz by producing harmonics.

Time weighted average (TWA):

An 8 hours time-weighted average sound level is the sound level that would produce a given noise dose if the individual were to be exposed to that sound level continuously over an 8 hour work day.

Transiently evoked otoacoustic emissions (TEOAE):

Those sounds, originating in the cochlea, which occur as a form of "echo" produced by a sound introduced to the ear. Also known as click evoked otoacoustic emissions (CEOAE).

Two tone rate suppression (TTRS):

The presence of one stimulus can affect the responsiveness of nerve fibers to other simuli, and if the relative frequencies and intensities of two tones are arranged correctly, the second tone can inhibit, or suppress, the response to the first.