OPEN ACCESS GUIDE TO AUDIOLOGY AND HEARING AIDS FOR OTOLARYNGOLOGISTS

NOISE AND HEARING IN OCCUPATIONAL SETTINGS

Lidia Pottas

In our modern industrialised civilization, hardly anyone can escape some exposure to noise. The link between the existence of excessive noise in the environment and the production of hearing loss in people working in the environment is beyond question. Therefore hearing conservation, in order to protect the individual from damage as the result of exposure to noise, becomes increasingly important.

*The word **conservation** is defined as "a careful preservation or protection of something: the planned management of a natural resource to prevent exploitation, destruction, or neglect" (Melnick, 1994: 534).*

Conservation and rehabilitation (attempts to minimise the handicap of hearing loss) form the foundation for the existence of the field audiology. In general the aims of hearing conservation are not appreciably different from the fundamental purpose of occupational hearing conservation. The reason why we label our efforts in the occupational environment as "occupational hearing conservation" is that we have been able to identify a noxious agent - intense noise - that has a pervasive effect on the hearing of people working in such environment.

NOISE & THE HUMAN BEING

Noise can be defined as being "unwanted sound" and for our purpose we can define it further as audible acoustic energy that adversely affects the physiological or psychological well-being of people.

Non-auditory effects of noise on human beings

Non-auditory effects of noise are effects that do not cause hearing loss, but have other real effects. Some of these effects are seen by a change in body functions, such as heart rate and stress related conditions, such as high blood pressure, coronary heart disease, ulcers, colitis and migraine headaches. Noise may also negatively influence learning in children. Other effects that have been reported include:

- Annoyance
- Decreased working efficiency
- Physiologic changes in muscle tension and blood circulation, dilation of pupils and changes in gastrointestinal motility
- Psychological distress
- Headaches
- Insomnia
- Fatigue

Several general conclusions regarding the effect of noise on the performance of mental or motor tasks have been formulated in the literature. It appears that steady, meaningless noise does not seem to affect performance at levels below 90 dBA, whereas random bursts of noise are more disruptive than steady-state noise. Components of the higher frequencies of the noise are more disturbing than the components of the lower frequency. Noise may also produce variability in the rate of work, *e.g.* periods when little or nothing is accomplished followed by periods of increased activity. Although noise may not reduce the quantity of work produced it may reduce the accuracy of work; and complex tasks rather than simple tasks are more likely to be affected by noise.

Auditory effects of noise on human beings

More directly auditory effects of noise include the obvious ***interference with speech communication*** caused by the masking produced by background noise and

the ***primary auditory effect of noise on hearing***.

Interference with Speech Communication

A communication system has 3 components: a sender (speaker); the channel (air) and a listener (receiver) *(Figure 1).*

Figure 1: Components of a communication system

The acoustic structure of the speech signal is complex and therefore it can be influenced by noise of any nature. The intensity of noise is but one aspect that must be considered. An important result of interference with communication is the inability to hear and consequently react to warning signals. This can have fatal consequences. Accidents are more likely to happen in areas where noise output is very high. Excessive noise can also cause workers to stop talking, to change content of conversations, to talk only when absolutely necessary and to frequently repeat what they are saying.

Primary auditory effect of noise on hearing

There is considerable variation in people's susceptibility to the effects of noise on hearing, which can be described in terms of:

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

Acoustic trauma

Acoustic trauma refers to the effects of a single exposure or few exposures to very high levels of sound *e.g.* an explosion. The sound levels reaching inner ear structures exceed mechanical limits of these structures and can result in a complete breakdown of the *Organ of Corti*. Exposure to a high intensity blast can also rupture the tympanic membrane. Audiologically such individuals present with a mixed hearing loss.

Temporary threshold shift (TTS)

A temporary threshold shift is a short-term effect that may follow exposure to noise causing overstimulation of the hair cells of the *Organ of Corti*. The sound levels must exceed 85 dBA. TTS is caused more by noise in the frequency range between 2000-6000Hz than by lower frequencies, and occurs within 2hrs of exposure. TTS increases with both increased intensity and duration of exposure. The elevated hearing threshold gradually recovers.

Permanent threshold shift (PTS)

A permanent threshold shift is a permanent (irreversible) shift of hearing threshold. It is the result of a TTS that becomes permanent gradually.

As various other hearing disorders cause the same configuration of hearing loss, the ***following aspects must be considered before a hearing loss can be diagnosed as "noise-induced hearing loss" (NIHL)*** *(Sataloff & Sataloff, 1987:357)**:***

- Hearing loss must be sensorineural (See *Figure 2* – Audiogram B which includes air- and bone conduction)
- The 1st indication of noise-induced damage is generally a ***"noise notch"*** which is a sensorineural dip in the audiogram around 4000 Hz *(Figure 2).* Although overall hearing thresholds may be within normal range, this notch is considered an early warning sign. The notch frequently deepens and the loss extends to other frequencies as the sensorineural hearing loss progresses

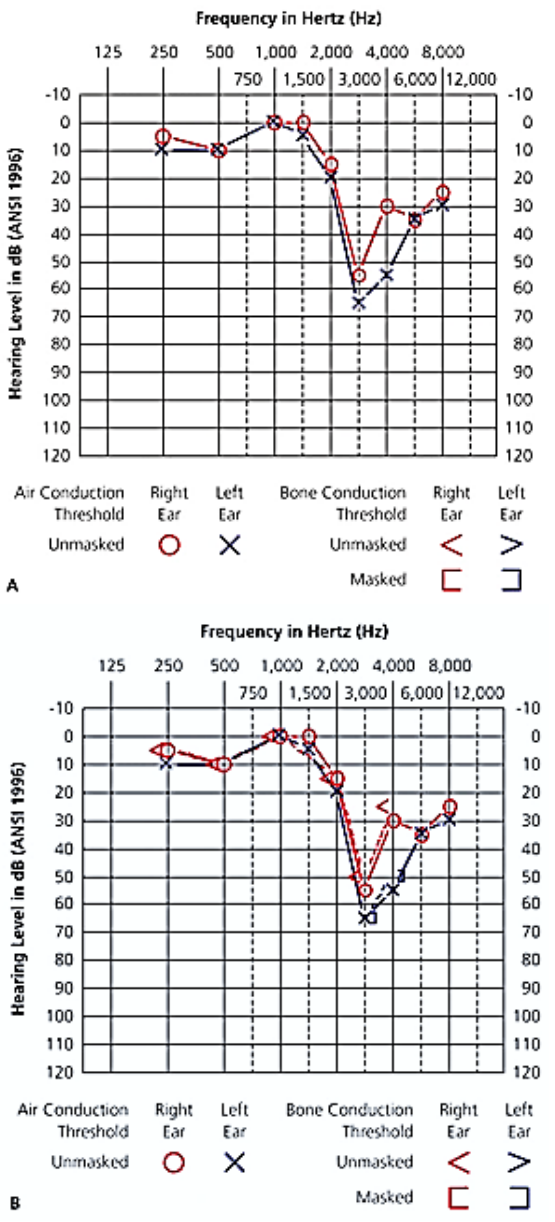

Figure 2: Typical NIHL: Air conduction (top); Air & bone conduction (bottom)

- There must be a history of long-term exposure to intense noise levels sufficient to cause the degree and pattern of hearing loss evident in the audiological findings
- Hearing loss must have developed gradually during the first 8-10 years of exposure
- Hearing loss must initially have started in the higher frequencies (3000-6000 Hz) and be almost equal in both ears
- Speech discrimination scores are generally relatively well preserved (>75%)
- Hearing loss should stabilise if the person is removed from noise exposure

The following important points should also be considered when diagnosing NIHL:

- Shifts in hearing threshold are currently the standard measure used to identify NIHL
- Yet substantial cochlear hair cell loss can occur before hearing thresholds are affected
- However otoacoustic emissions (OAEs) are being more commonly employed to provide an even earlier identification of NIHL
- If noise exposure is asymmetric, *e.g.* with firearms, the hearing loss may also be asymmetric. The loss will generally be ***worse on the side opposite to the person´s dominant hand*** because that ear receives the greatest impact when shooting with a rifle or revolver
- Symptoms related to NIHL are similar to high-frequency sensorineural hearing loss from other causes *i.e.* difficulty understanding in background noise, trouble understanding high-pitched voices and "hearing but not understanding". In most cases patients understand vowels, but not consonants, rendering it difficult to distinguish speech
- NIHL may be accompanied by tinnitus, which may be the most persistent and aggravating symptom. Some experience "diplacusis", which is an inability to perceive a sound's pitch correctly. However these symptoms may also occur with other aetiologies
- The absence of PTS or a noise notch in the audiogram does not exclude NIHL

Vulnerability

Some are especially vulnerable or at-risk for NIHL:

- A pre-existing sensorineural hearing problem
- History of genetic deafness, noisy hobbies, military service
- Smokers (1.7 x more vulnerable)
- Hearing loss greater than expected from previous noise exposure
- Exposure to certain industrial chemicals
- Certain medical conditions (diabetes)
- Using certain medications *e.g.* salicylates, quinine etc.

DAMAGE RISK CRITERIA (DRC)

The term "*damage risk criteria"* refers to criteria for the risk of acquiring NIHL as a consequence of a given noise exposure, as well as the accepted limits of a particular occupational noise. It provides criteria for deciding on the acceptable limits of noise exposure and considers the hearing loss that can be expected at specified audiometric frequencies in a specified percentage of people exposed to a given noise over a stated time period.

Many factors must be considered when setting of damage risk criteria:

- Overall level and type of noise
- Frequency composition of noise
- Duration and distribution of exposure
- Acceptable threshold shifts

Damage risk criteria must be set for:

- Continuous broadband noise
- 8-hour shift per day
- 5 days a week
- 15-year exposure time

A number of damage risk criteria are used. The best-known noise specifications are part of federal regulations resulting from the *Occupational Safety and Health Administration (OSHA)* as developed by the *American Conference of Governmental Industrial Hygienists,* and the specifications according to the *National Institute for Occupational Safety & Health (NIOSH) (Table 1).*

Exposure level (dBA)	Duration of exposure (hours)	
	OSHA (1983) 5 dB exchange rate	NIOSH (1998) 3 dB exchange rate
85	16	8
88		4
90	8	
91		2
94		1
95	4	
97		30min
100	2	15min
103		7min 30s
105	1	
106		3min 45s
109		1min 53s
110	0.5 (30min)	
112		56s
115	0.25 (15min)	28s
118		14s
120	0.125 (7min 30s)	
121		7s
124		3.5s
125	0.063 (3min 47s)	
127		1,75s
130	0.031 (1min 52s)	0.88s
140	0.0078 (28.1s)	< 0.1s

Table 1: Damage risk criteria: duration limits for selected exposure levels

Note that in the case for *OSHA* regulations, a 5 dB "exchange rate" is used and compared with the 3 dB "exchange rate" recommended by *NIOSH*. This time-intensity relationship implies that an increase in dB exposure levels (whether 3 or 5 dB) requires halving of exposure levels, or a decrease in dB exposure level allows doubling of the exposure time.

Examples of other damage risk criteria include:

- *U.S. Environmental Protection Agency (EPA):* No hearing loss as a result of

noise exposure is accepted and the criteria must include measurement of hearing loss at 4000 Hz
- *American Conference of Governmental Industrial Hygienists (ACGIH*): Hearing loss only at 500, 1000, and 2000 Hz is considered, which has been judged to affect verbal communication. The degree of accepted hearing loss is <25 dB for the average of these frequencies.

Other factors also influence the risk of PTS. Safe damage risk criteria for the population in general might not be safe levels for individuals who are more susceptible for NIHL *e.g.* simultaneous exposure to ototoxic drugs or industrial chemicals may aggravate the damaging effect of noise on the inner ear.

NOISE SURVEYS

The hazard posed by noise depend on its intensity, spectrum, duration and distribution of exposure during a typical workday, and the overall exposure during a working life. Each of these factors must be evaluated to determine the risk they pose to hearing in order to institute steps for noise control and hearing conservation programmes. A thorough evaluation of the physical properties of noise is an essential first step to the development of a hearing conservation programme or of noise control procedures

Noise surveys are generally conducted for two reasons:

- Evaluate the hazards of noise for employees so that suitable protective measures may be taken to conserve hearing
- Obtain information concerning the noisiness of machinery or manufacturing processes to improve design or method of installation

Detailed analysis of the noise field is a complex, highly technical task and requires a considerable amount of judgment in determining where measurements should be made and what kinds of analyses should be performed. The validity of the measurements obtained is in direct proportion to the degree of knowledge on the part of the individual conducting a survey. Therefore it requires extensive training on the part of the person performing the analysis.

Principles of Noise Surveys

- Measurements must be performed at least once for those who are exposed to noise of $\geq$ 85 dBA
- Re-measurement must take place when a change in equipment or a work procedure could potentially cause significant increase in exposure
- Assessment of the sound environment must include all continuous, intermittent and impulsive noise of 80 -130 dBA

Sound Level Meters for Noise Surveys

Sound level meters are used to measure various frequency and time-weighted sound pressure levels. It consists of a microphone, amplifier, attenuator circuit, 3 ***frequency-weighting networks*** (A, B & C) and a visual meter *(Figure 3).*

Frequency weighting networks

You might be wondering what a ***frequency weighting network*** is? This is important to understand, as the network that is used is indicated in the noise level *i.e.* 85 dBA. It can be explained as follows:

- The human ear can detect sound frequencies between 20 and 20,000 Hz
- Our hearing is however most sensitive near the centre of this frequency range

Figure 3: Sound level meter

- Hence high-intensity high or low frequency sounds may seem softer than a less intense mid-frequency sound
- The human ear does not respond well to low frequencies at low sound pressure levels - SPLs. As the sound increases in intensity, the ear becomes more capable of low frequency responses
- It is useful to employ frequencies that the ear is most sensitive to
- ***Three frequency-weighting networks (A-, B-, and C-weighting networks)*** normalise the intensity of the sound according to the human ear's sensitivity
- Each of these networks correspond with the human ear's sensitivity to sounds of relatively low, medium and high intensity
- The ***A- weighting network*** simulates the frequency response of the human ear to low sounds and therefore gives a good estimation of the threat to human hearing
- The ***B frequency-weighting network*** is for measurement of environmental noise and is not used in the context of hearing conservation
- Although many modern sound level meters include a facility for ***C-weighting***, it is only used for noise control engineering applications and for impulse noise peak measurements

The frequency-weighting network that is used is indicated in the specific noise level, i.e. 90 dBA. Sound level meters usually have two types of response characteristics built into the meter *i.e.* ***fast response*** and ***slow response.***

The ***fast response*** enables the meter to measure levels that do not change substantially in < 0.2 seconds.

The ***slow response*** is intended to provide an averaging effect that reduces fluctuations of sound levels and makes these noise levels easier to read. This setting will not provide accurate readings if the sound levels change in < 0.5 seconds.

These responses cannot however be used to measure impulse or impact types of noise as the acoustic properties of these noises require special equipment or special circuits in sound level meters. ***Current guidelines and specifications require that the A-frequency weighting network and the slow meter response are used on sound level meters when measuring hazardous noise levels.***

Noise Dosimeter (Figure 4)

Personal noise dosimeters are used to measure the noise exposure experienced by an

individual as it is difficult to do so with a sound level meter as the noise environment is likely to fluctuate during the course of a workday because of changes in the noise source as well as in the employee's position in the noise field.

- The microphone of the dosimeter is mounted on the shoulder, or chest or at the ear
- It integrates the A-weighted sound pressure over a period of time and (usually) compares the measured exposure with a criterion sound exposure *e.g.* with an 8-hour exposure to 90 dBA

Figure 4: Noise dosimeter mounted on the shoulder

How to conduct a Noise Survey

- Ensure that all equipment is calibrated and in perfect working order
- Select the locations where measurements are to be recorded
- Capture accurate readings of the overall levels at each location with a sound level meter
- Plot and label these locations on a floor-plan of the room
- Record octave-band measurements and/ or tape recordings for later spectral analysis at each location
- Recheck overall levels of noise to ensure that the levels of noise have not fluctuated appreciably since the time of the initial recordings and check the accuracy of the first readings
- Construct a diagram that shows the measurements at the various locations *e.g.* noise contour plot *(Figure 5)*

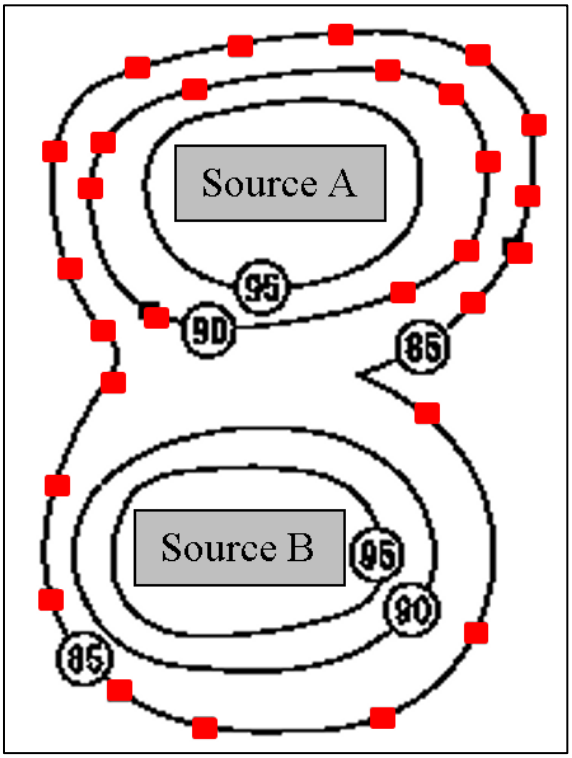

Figure 5: Noise contour plot (measurement points ■)

NOISE CONTROL

Noise control may be desirable to reduce the likelihood of causing NIHL, to improve communication between workers, and to reduce annoyance. It is however technically very demanding and should be undertaken by acoustic engineers or with the help of acoustic consultants (if available).

Noise exposure may be controlled in several ways:

Reducing noise produced at source

- *Acoustic design of equipment:* Mechanical parts of machines can be designed with relatively noiseless material
- *Modification of machine design:* This can be achieved by reducing the energy available at the source of the vibrating system, changing the coupling between the vibrating system and the sound radiating system, or by changing the structure that radiates the sound so that less is radiated.
  - Substituting activity-creating noise or change to quieter processes
  - Using screws instead of nails
  - Eliminating hard surface-to-hard surface contacts in processes e.g. metal to concrete
- *Keeping equipment in good working order*
- Implementing the above measures is however not always practical or possible

Reducing transmitted noise

- *Change physical relation between worker and noisy machinery*
  - Doubling the distance from the source reduces the SPL by 6 dB
  - Increase the distance between the employee and the noise source
  - Rotate workers around a noise source to ensure minimum individual exposure
- *Change the acoustic environment*
  - Add acoustic absorbing material to the room in which the machinery is located
  - Reduce air velocity of fans.
- *Enclose machinery to contain the noise*
  - Use attenuating structures *e.g.* walls, standing or hanging barriers
  - Totally enclose the sound source
- *Enclose the operator to shield him from the noise:* Place the worker (instead of the machinery) in a protective booth; this may be the best solution particularly with very large machinery

Active noise cancellation

When a sound wave encounters another sound wave that is identical other than having a phase shift of 180 degrees, the peaks and troughs of the original sound waveform are cancelled by the peaks and troughs of the 2nd waveform; this process is referred to as ***destructive interference***. This can be accomplished by placing a microphone near the device producing the high level noise, amplifying this noise to a high level and then sending it through a device that adjusts the phase of the noise wave through 0 to 360 degrees. This phase-shifted noise is then sent to a loudspeaker located at some distance from the noise source. A 2nd sound wave is then created and placed back into the environment where the 1st sound wave is present. ***This results in a reduction of sound energy in the environment.***

Protecting the worker

If the above-mentioned methods for noise control are not possible, the next most desirable method is to reduce the risk of NIHL through:

- ***Administrative controls***
- ***Changes in work schedules***
- ***Hearing protectors****:* If neither of the above solutions are possible

Hearing protectors serve as barriers between the noise and the inner ear. The protection provided by hearing protectors depends on the design and the physical characteristics of the person wearing it. It is extremely important that the protection is used continuously as removing protection in noise for 5 minutes considerably reduces

its protective value, for >1 hour /day almost totally eliminates the protective value.

Two basic types of hearing protectors are ***earplugs***, which are inserted into the external ear canal; or ***muffs***, which are worn over the external ear and provide an acoustic seal against the head. Earplugs and muffs ***can be worn simultaneously***. *Table 1* presents a comparative summary of the earplugs *vs.* earmuffs

	Advantages	Disadvantages
Muffs 	Single size fits most heads Special fitting not required More efficient at attenuating sound More readily accepted by workers More comfortable Not easily lost Can ensure compliance as visible at a distance	Possible problems getting a seal when worn with glasses Uncomfortable in hot environment Higher initial cost Can be fitted into protective headgear Protection depends on spring force of headband; through usage the force may be considerably weakened, and protection significantly reduced
Plugs 	Small and easily carried Convenient More comfortable in hot environment Cheaper Convenient to use when the head of wearer is in closed, cramped space	More time and effort to fit Generally less protection and variable between wearers Can become dirty and unsanitary Difficult to ensure that workers wear them as they are difficult to see at a distance Can't be worn with external or middle ear infection

Table 1: Comparison of hearing protection devices (HPDs)

Both earplugs and earmuffs provide sufficient attenuation to offset hazardous noise exposure typically found in occupational environments. The biggest problem however is to motivate workers to wear protectors, as not one type satisfies all. It may be advisable to stock a variety as there are advantages and disadvantages to both these types of protectors *(Table 1).*

Earplugs (Figure 6)

Many types of earplugs are commercially available:

- ***Semi-permanent*** moulded soft rubber or plastic plugs are available in 4-5 sizes for different sized ear canals
- ***Disposable*** plugs are made of materials as wax, silicone putty or slow recovery foams. They are made of non-porous, easily formed materials and are shaped by the wearer. It is usually for short-term use

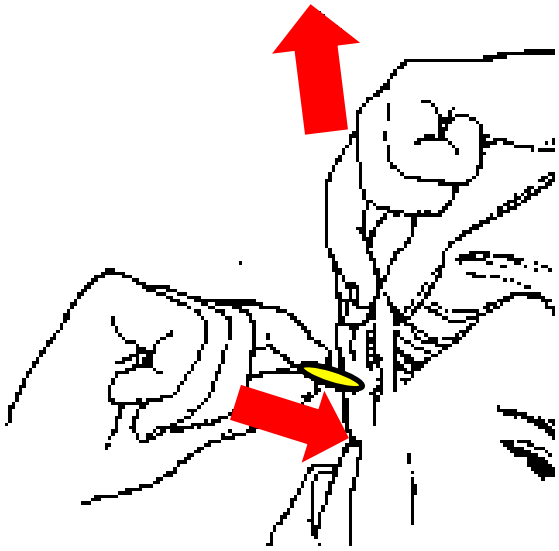

Figure 6: Method of inserting an earplug

Earmuffs (Figure 7)

Most earmuffs are similar in design and consist out of a hard shell (cup) fitted into a soft, pliable seal, generally made of a smooth plastic envelope filled with a foam or some fluid material.

Figure 7: Example of occlusive ear muffs

HEARING CONSERVATION PROGRAMMES

A hearing conservation program is *instituted to protect the hearing of workers from the effects of hazardous noise exposure at their working place.* A well-planned program founded on concerns for employees' health and which is rich in educational groundwork is likely to succeed.

Every hearing conservation program, even in a small industry, requires teamwork. The team usually consists of the medical, hygiene, and safety departments; management, supervisors and labour representatives *(Figure 8).* Every team member should monitor proper use of hearing protection.

A hearing conservation programme should include aspects such as preventing sensorineural hearing loss due to noise exposure and minimizing an employer's liability for compensation claims for NIHL. It should also minimize non-auditory effects of noise on workers and should identify workers with ear and hearing problems unrelated to noise exposure.

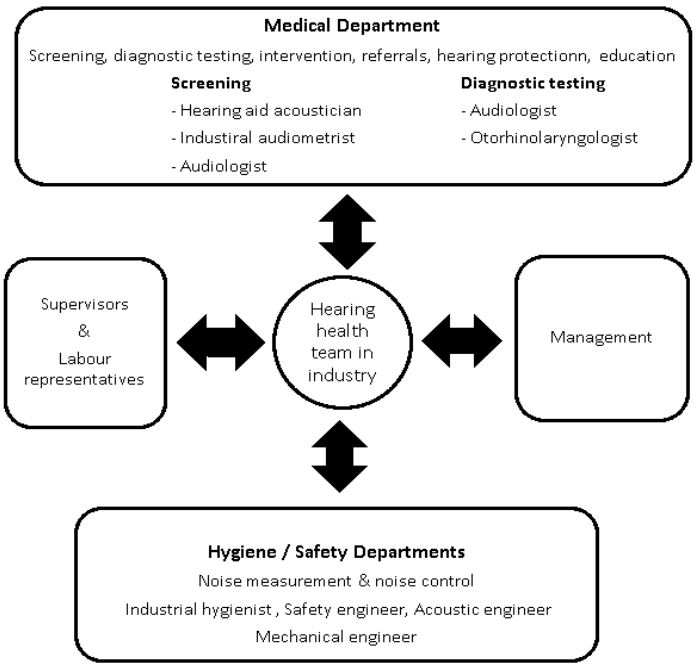

Figure 8: Hearing health team in industry

Not infrequently managers of industries believe that they have an effective hearing conservation programme because they have performed thousands of hearing tests and numerous noise measurements. However, when they are asked what the audiograms show and whether employees are using hearing protectors, the answers are often unsatisfactory. Quite often they admit that they don't understand what the reports mean and that they don't really know whether employees are using hearing protectors properly.

To ensure an effective hearing conservation programme, *Sataloff & Sataloff (1987:625)* suggest the following to be considered:

- A responsible and trained member of the industry must supervise the programme and focus specifically on proper use of hearing protectors
- A well-trained person should conduct a complete noise survey of all areas with a sound level meter
- On the basis of these measurements it is decided whether a hearing conservation programme is required and whether

noise control is technically and economically feasible
- A noise control programme focussing on aspects as discussed above should be implemented *(Table 2)*

Full cooperation and complete support of management and labour leaders essential to maintain a successful hearing conservation programme	***Every abnormal audiogram evaluated*** by an audiologist to establish a diagnosis
Expert ***consultants*** readily available for analysis & management of problems	All employees ***use hearing protectors*** in noisy areas that are so marked
Education, promotion, and encouragement should be constant ingredients	***Management and supervisory personnel must also wear hearing protection***, preferably muffs, for high visibility of compliance with hearing conservation programme
Everyone must be included in programme, not only employees exposed to noise	Employees ***permitted to select*** from several types of acceptable hearing protectors and new ones provided in case of loss
Monitoring audiometry kept up-to-date and results used for constant evaluation of hearing conservation programme	***Hearing protectors properly fitted*** and worn
Hearing tests done routinely on all employees, including management and not only restricted to personnel exposed to high noise levels	***Allow trial periods*** with free exchange of protectors
Employees must have ***audiogram just prior to leaving a company***	***Referral to ENT*** when there is *e.g.* progressive hearing loss, reactions to hearing protectors, otitis media or external otitis
Audiograms are done ***when employee has not been exposed to noise for >16 hrs***	

Table 2: Features of successful hearing conservation programmes

- The hearing-monitoring programme should be implemented and certified personnel using equipment and test rooms that meet the necessary standards must perform the testing
- An ENT/audiologist certified in hearing conservation should interpret all audiograms
- A hearing protection programme, focussing on effective use of hearing protectors should be instituted
- An educational programme about hearing conservation, essential for management and employees should be provided on a continuing basis

OCCUPATIONAL HEARING TESTING

Hearing tests are used to monitor the impact of noise on workers' hearing and to evaluate measures to control NIHL. Hearing threshold levels are determined over a specified range of frequencies (500, 1000, 2000, 3000, 4000, 6000, 8000 Hz, and may also include 125 and 250Hz).

In terms of ***occupational audiometry*** it is important to take note of the following:

Test Environment

Reliable measures of hearing sensitivity require that ambient background noise levels in the test environment be sufficiently low to avoid interference with the measurement. Visual and acoustic interferences should be limited. Aspects such as sound absorbent material/isolation should, comfortable furniture and proper ventilation should be considered.

Audiometric Equipment for Screening

Criteria: Audiometers used for periodic screening must comply with international audiometry standards, and must provide

testing at frequencies 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz.

***Calibration and verification checks**:* If threshold measurements are to be reliable and accurately indicate hearing status, audiometers must be accurately calibrated. Daily maintenance and checking is very important. Biological calibration should be conducted at least once a week, depending on the number of daily tests. Daily self-listening checks should be conducted to confirm that the audiometer is functioning effectively. Permanent records should be kept of all calibration data. Periodic and exhaustive calibration checks should be regularly conducted or when the audiometer is found to be malfunctioning or out of calibration.

Test Personnel

While baseline audiograms, screening, monitoring and exit audiograms can be conducted by an occupational nurse, acousticcian or occupational audiometrist, complete diagnostic testing can only be performed by an audiologist in cooperation with an ENT specialist.

Procedure for Occupational Hearing Tests

Audiometric evaluation is the only way to determine an individual's susceptibility to NIHL. An estimate can be made of how the worker is being affected by comparing results of periodic examinations. Those who are particularly sensitive to noise can be identified and referred for further diagnostic testing to determine the exact nature and degree of hearing loss and for further intervention.

Screening Procedures in Industry

The following screening procedures are included in a hearing-monitoring program:

- ***Baseline audiogram:*** The 1st audiogram of a new employee is called the baseline audiogram and serves as a reference with which future audiograms are compared to determine whether changes, if any, have occurred in hearing. If possible this audiogram should be obtained before the employee commences work
- ***Monitoring audiometry:*** Periodic retesting of hearing with *no prerequisites in terms of pre-test conditions* of subjects as the purpose of the test is to identify early temporary threshold shifts (TTS) due to noise exposure. These results are important in the evaluation of an individual's hearing protection devices and the use thereof
- ***Occupational screening audiometry:*** This refers to *mandatory annual audiometric testing* to determine an individual's hearing threshold levels. It is performed on all employees exposed to noise levels of $\geq$85 dBA and must be preceded by a period of at least 16 hours of no exposure to high levels of noise. The reason for this is to rule out the possibility of TTS´s as this can affect the results. The aim of the last screening audiogram is to determine if there is significant change in hearing levels at any frequencies since the previous test
- ***Exit audiometry:*** This is audiometry performed at the conclusion of employment in a noise zone, and must form part of an employee's medical record
- ***Diagnostic audiometry:*** Specialist evaluation of hearing through pure tone audiometry (air- and bone conduction), speech audiometry and further special diagnostic tests as indicated

Problems typically encountered with screening programs in industry

- Failure to define in measurable terms what the screening is attempting to identify
- Failure to maintain confidentiality
- Failure to confine screening to tests having a high degree of validity or accuracy
- Errors due to screening tests being administered by poorly trained personnel
- Noise in the test area
- Too long test sessions
- Failure to differentiate between a positive screen and a positive diagnosis
- Failure to monitor screening programmes

Record Keeping

Keeping accurate records is important because of the potential for compensation claims and the legal implications. The employer needs to ***maintain accurate records*** of the following:

- ***Noise exposure measurements***
  - Location, date and time of measurements
  - Noise levels obtained
  - Name of the person making measurements
- ***Names of employees and daily dose of noise exposure*** of each
- ***Noise-measuring equipment***:
  - Names, types and calibration
  - Date of last acoustic calibration of the audiometer
- ***Background noise levels*** in audiometric test rooms
- ***Audiometric test results*** of employees
  - Name, job classification
  - Date of audiogram
  - Name of tester
  - Assessment of employee's most recent noise exposure

Hearing Conservation Education

Education of both management and employees is critical to developing a successful hearing conservation programme. Apart from efforts to minimise noise levels through noise control, hearing conservation education is promoted through worker orientation, job instruction, training, and poster exhibits of hearing protection devices, and safety talks. Warning signs should be posted at entrances to high-noise areas and should instruct workers to wear hearing protectors.

Hearing conservation education should keep the following in mind:

- Recognised standards such as that of the *Occupational Safety & Health Administration* (1983)
- Management, supervisors and employees should all be included in a comprehensive education programme on the function of the ear, physical and psychological effects of noise and hearing loss, preventative and corrective measures should damage occur or if unusual deterioration is detected
- Employees exposed to noise that exceeds the maximum advisable levels should be required to wear hearing protection devices. To achieve maximum utilisation of such devices, a programme requires cooperation and the very best levels of understanding between management, supervisors and employees
- Training and education should be provided annually to those exposed to >85dB noise
- Regular educational activities should be conducted throughout the year
- Education programmes should be simple to understand, and should summarise the most important aspects of a conservation programme and motivate

employees to give their full participation

Suggested topics for a Hearing Conservation Education Programme

Topic 1: Why is hearing protection important for you?

- Can reduce noise exposure and lessen the amount of noise-induced hearing loss (NIHL)
- May help to reduce tinnitus (ringing in ears)
- Can improve communication
  - Speech communication
  - Awareness of warning signals
- Can prevent effects on job performance
  - Fatigue
  - Irritability
- Can prevent extra-auditory effects
  - Stress diseases
  - Sleeplessness

Topic 2: Maintenance and care of hearing protective devices

- Hygiene
  - Pre-moulded earplugs should be washed
  - Disposable plugs should be discarded after each shift or if they become dirty
  - Cushions of earmuffs should be wiped clean
  - Hearing protection should not be used in the presence of an ear infection
- Replacement
  - Pre-moulded plugs shrink and harden over time and should be replaced if this occurs
  - Earplugs should return to original shape when removed from the ear; otherwise they should be discarded
  - Earmuffs should be checked to ensure a good seal against the head
  - Headbands weaken with age and may lose their spring
  - Cushions eventually harden and fail
  - Ear cups can become brittle and crack with age
- General requirements
  - Proper initial fit
  - Used correctly
  - Training in use and care of available hearing protectors
  - Allow to select hearing protectors from a variety of suitable hearing protectors provided by employer
  - Replaced as necessary
  - Wear hearing protection if need to shout to be converse with someone within 2 or 3 feet away
  - Never remove hearing protection in high noise areas
  - Hearing protection recommended for high noise off-the-job activities *e.g.* woodworking, shooting, power tools, lawn mowers
  - Do NOT share hearing protection with others

CLOSING COMMENTS

Hearing conservation in occupational settings can be a challenging, yet very rewarding area of professional practice. The biggest challenge remains the lack of public awareness of the hazards of noise exposure. It is important that individuals realise that exposure to loud noise at work can permanently damage hearing. Excessive noise may also increase the risk of accidents in dangerous workplaces when it interferes with communication and concentration. This can negatively affect productivity and create unnecessary costs to individuals and businesses. It is therefore important to counteract these consequences of noise exposure.

Above all occupational hearing conservation programmes aim to protect and con-

serve one of our most valuable possessions: the sense of hearing.

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Author

Lidia Pottas PhD
Dept of Speech-Language Pathology and Audiology
University of Pretoria
South Africa
lidia.pottas@up.ac.za

Editors

Claude Laurent MD, PhD
Professor in ENT
ENT Unit
Department of Clinical Science
University of Umeå
Umeå, Sweden
claude.laurent@ent.umu.se

De Wet Swanepoel PhD
Professor
Department of Communication Pathology
University of Pretoria
Pretoria, South Africa
dewet.swanepoel@up.ac.za

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

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