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Te Kaporeihana Āwhina Hunga Whara



Assessment of occupational noise-induced hearing loss for ACC

A practical guide for otolaryngologists

January 2011



NZSOHNS

THE NEW ZEALAND SOCIETY OF
OTOLARYNGOLOGY, HEAD AND
NECK SURGERY.



INTRODUCTION

This Guide provides practical information for assessors providing specialist assessments for ACC occupational noise-induced hearing loss clients. It includes summaries of major literature reviews commissioned by ACC on key aspects of background information, as well as references to resources to assist assessors in providing high quality, evidence-based reports.

Background information on relevant legislation and specific details of the New Zealand context, including useful guidance on carrying out assessments for third parties, are included.

Current versions of key forms are presented in the Appendices – specifically the client-completed history form (ACC724) and the assessment form (ACC723). Both of these have been redesigned as part of the interaction between ACC and representatives of the New Zealand Society of Otolaryngology, Head and Neck Surgery.

If you require further information, please contact Anne Greville, Audiology Adviser, ACC, by email at anne.greville@acc.co.nz or by phone on 09 354 8473.

The Guide was endorsed by the New Zealand Society of Otolaryngology, Head and Neck Surgery on 26 December 2010.

Members of the Working Group for this document:

Anne Greville PhD, Audiology Adviser, ACC

Mr John Gilbert FRCS FRACS

Mr Bill Baber FRCS FRACS

Dr Margaret Macky, Director, Workwise Wellington, ACC

Peter Larking PhD, Senior Research Adviser, ACC

Zhi-ling Zhang, MB, MPH, Senior Research Adviser, ACC

Tanya Skaler, MB, MPH, Programme Manager, ACC

Note: There is an electronic version of this document, which will be updated from time to time, available at: <http://www.acc.co.nz/for-providers/clinical-best-practice/index.htm>

RELEVANT LEGISLATION IN NEW ZEALAND

Accident Compensation Act 2001

ACC provides comprehensive, no-fault personal injury cover for New Zealand residents and visitors to New Zealand. The Act precludes litigation for personal injury in New Zealand, except for exemplary damages.

Everyone in New Zealand is eligible for comprehensive injury cover, even if the client contributed to the injury. A claim can be lodged regardless of the client's age or whether they're still working.

Physical injuries covered by ACC can include: fractures induced by external trauma; work-related gradual process injuries (such as deafness caused by noise at work); infections or diseases caused at work by performing a particular task or being exposed to a particular environment (this excludes any congenital conditions); and poisoning.

As physical injury requires actual damage to the body from the injury, the mere presence of symptoms, such as pain or tinnitus, will not be sufficient to establish cover in the absence of a diagnosed physical injury.

ACC does not cover:

- illness (apart from certain defined occupational diseases)
- injuries related mainly to ageing
- injuries that develop gradually and are not caused by work tasks or exposure (i.e. non-occupational gradual process injuries).

Under normal circumstances, the injury must have occurred in New Zealand.

Specific legislation relating to hearing loss

ACC can provide cover for hearing loss when it is caused in the following ways:

- an accident
- a gradual process condition (but only if related to work exposure), or
- medical treatment (known as treatment injury).

Work-related hearing loss

The Accident Compensation Act 2001 allows cover for noise-induced hearing loss (NIHL) as a work-related gradual process injury.

To be eligible, the client needs to establish that they were resident and working in New Zealand or working temporarily abroad as a New Zealand resident for a New Zealand agency or company when the noise exposure occurred.

For hearing loss to be accepted for cover:

- the hearing loss must be caused by noise
- the exposure to noise needs to be identified as having occurred *at work* and
- the exposure to injurious noise must not have occurred to a material extent away from work (material extent meaning that the non-work exposure acting alone could not have been sufficient to cause the NIHL)

- workers exposed to such workplace noise must be at significantly greater risk of suffering NIHL compared with others not exposed to that environment. The comparison of risk is between people who generally perform work with such noise exposure and people in other work environments, not between the client and the general population. The fact that a client may be more at risk of suffering NIHL is not relevant to this consideration
- the work must be for pecuniary gain or profit – unpaid work, or work that involves only an allowance which is not subject to taxation (such as volunteer firemen, prisoners involved in work schemes) is not covered

Accidents

Hearing loss can result from head injuries caused by accident. This generally requires specialist assessment, and is outside the scope of this Guide.

Occasionally hearing loss may result from a single exposure to an extremely loud noise or explosion. The nature of the assessment for these cases will differ from assessment for gradual process because it will be limited to evidence relating to hearing loss suffered on a given date.

Treatment injury

Treatment injury cases include those with hearing loss caused by treatment provided by a registered health professional, when hearing loss is not a necessary part or ordinary consequence of the treatment. Determination of treatment injury involves consideration of all the circumstances of the treatment, including the person's underlying health condition at the time of the treatment, and clinical knowledge at the time of the treatment. The failure of treatment to achieve the desired result is not considered to be a treatment injury.

Cover

For clients who lodged a claim on or after 1 July 2010, a 6% hearing loss threshold for cover applies. That is, the amount of hearing loss attributed to occupational noise-induced hearing loss (ONIDL) (or other covered cause) must exceed 6% for ACC to accept cover. This does not apply to clients with existing claims lodged before July 2010. Where there are several claims (such as for trauma) cover may be given if the total hearing loss exceeds 6%.

Entitlement/s

Before the introduction of the 6% threshold for cover, not all clients who were eligible for cover were also eligible for entitlements (i.e. rehabilitative assistance such as hearing aids and associated services). Under current legislation, this is less likely; instead, regulations control the extent of entitlement.

ACC Regulations

Specific details relating to assessment of hearing loss are contained in the Accident Insurance (Occupational Hearing Assessment Procedures) Regulations 1999¹. Under these regulations, the percentage loss of hearing (PLH) scale is defined, together with corrections for age-related hearing loss. Note that the age correction table was updated in 2010.

The percentage loss of hearing scale was developed by John Macrae at the National Acoustic Laboratories in Sydney, Australia, and a discussion of the development of the scale² is presented at: <http://www.acc.co.nz/for-providers/clinical-best-practice/hearing-loss>.

¹ <http://www.legislation.govt.nz/regulation/public/1999/0167/latest/DLM286720.html>

² Greville A. The NAL percentage loss of hearing scale. ACC report, February 2010

The Accident Compensation (Apportioning Entitlements for Hearing Loss) Regulations 2010³ specify maximum payments towards the cost of hearing aids and associated service fees under an apportionment model; that is, the amount paid reflects the proportion of the total hearing loss attributed to the covered injury. In addition, the Ministry of Health subsidy is reverse-apportioned. Payments on behalf of both ACC and the Ministry of Health are administered by ACC for clients with hearing loss of mixed causation. In most cases, clients would be liable for some degree of co-payment.

Health and Safety in Employment Act 1992

The objective of the Health and Safety in Employment (HSE) Act is to promote the prevention of harm to all people at work, and others in, or in the vicinity of, places of work. The Department of Labour administers and enforces the HSE Act in most workplaces.

The Act applies to all New Zealand workplaces and places duties on employers, the self-employed, employees, principals and others who are in a position to manage or control hazards.

The emphasis of the law is on the systematic management of health and safety at work. It requires employers and others to maintain safe working environments, and implement sound practice. It recognises that successful health and safety management is best achieved through good faith co-operation in the place of work and, in particular, through the input of those doing the work.

Employers should have an effective system for responding to and managing the hazards that they identify. How the employer responds to and manages a particular hazard will depend on the circumstances.

The preferred response is to **eliminate** the hazard, that is, change things so the hazard no longer exists. If this can't reasonably be done, the next response should be to **isolate** the hazard by putting in place a process or mechanism that keeps employees away from the hazard. If this can't reasonably be done, the hazard must be **minimised**, that is, do what can reasonably be done to lessen the likelihood of harm being caused by the hazard and to protect employees. This might include:

- providing employees with suitable protective clothing or equipment
- monitoring employees' exposure to the hazard
- with their informed consent, monitoring employees' health in relation to the hazard.

In addition, regulation 11 of the Health and Safety in Employment Regulations 1995 contains specific workplace noise exposure limits and requirements to warn where these are exceeded.

The regulation requires employers and others in control of workplaces to ensure workers are not exposed to hazardous workplace noise with or without hearing protection (generally considered to be greater than 85 dB(A) for eight hours' exposure or equivalent, with a halving of exposure time for every 3 dB of average intensity, and a maximum permissible peak intensity of 140 dB). If it is not possible to control exposure to the noise, hearing conservation measures must be provided (and employees and others in the workplace are obliged to participate in these).

The Act also requires employers to measure and keep records of workplace noise levels in noisy occupations and industries, as well as to regularly test the hearing of exposed workers. Provision of hearing protectors does not imply that no dangerous noise exposure has occurred – various reports have outlined the limitations of hearing protection⁴.

³<http://www.legislation.govt.nz/regulation/public/2010/0424/latest/DLM3344620.html>

⁴ Thorne PR. Best practice in noise-induced hearing loss management and prevention: a review of literature, practices and policies for the New Zealand context. Auckland UniServices, November 2006
http://www.acc.co.nz/PRD_EXT_CSMP/ideplg?IdcService=GET_FILE&dID=4620&dDocName=WIM2_065096&allowInterrupt=1

ASSESSMENT ISSUES

You can see from the legal framework that aspects of your clinical assessment are vital, for example:

- your careful elicitation of the history of hearing loss, past illness, injury, treatments and noise or explosion exposure
- your expert opinion about the pattern of hearing loss and examination findings, and whether these are typical of NIHL
- your expert analysis of the severity of the noise exposure
- your expert analysis of the relative risks of work and non-work exposure
- your expert opinion on the risk to hearing from the client's medical, surgical, pharmacological or trauma history
- your understanding of the literature relating to work risk of NIHL in various worker groups and occupation types.

Medical Council of New Zealand

The Medical Council has developed guidelines for doctors carrying out medical assessments for third parties⁵ (see Appendix D). The guidelines cover issues such as the need to provide an impartial opinion for the third party, and the difference in the nature of the relationship between the doctor and the patient (notwithstanding the requirement to provide a professional standard of care). The doctor must communicate with the patient in a manner that enables the patient to understand the information provided and the role of the doctor as an assessor. The assessment report is sent to the third party (but in the knowledge that the report will be provided to the client on request).

A consideration of ethical behaviour and appropriate management of financial relationships (such as ownership of audiology services) is also provided by the Medical Council⁶.

Undertaking the assessment

There are specific clinical and ethical considerations to remember when undertaking a clinical assessment as a non-treating doctor.

(1) The specialist must be suitably qualified to undertake the assessment

The report you provide will be suitable for determining ACC cover and entitlement only if you have the skills and knowledge to undertake the assessment. You need to have a New Zealand vocational registration with ORL qualification which provides assurance of skills in history and examination at a specialist level. This is a baseline qualification. As well as this you should ideally have pursued an interest in hearing loss and be adept at analysing the hearing effects of illness, injury, medical treatment and noise exposure. It is also very helpful to be familiar with the literature on occupational and recreational risk of NIHL, including an understanding of medico-legal aspects of these conditions.

In situations where you feel your knowledge and qualifications are not sufficient to enable you to confidently undertake the assessment, it may be better to decline to do so, or at least to express some reservations when making the report.

(2) Patient communication, informed consent and explanation remain very important

Although you are not the treating doctor, as an assessing doctor you still have obligations to the patient. The Medical Council provides guidance on this subject and emphasises the approach to informed consent, checking the patient has a good understanding of the nature of the assessment and giving the patient some sense of what will happen next.

⁵ Medical Council of New Zealand. Non-treating doctors performing medical assessments of patients for third parties, December 2010

⁶ Medical Council of New Zealand. Good medical practice: a guide for doctors (sections 93-96), June 2008

There will be only limited situations where it is reasonable and expedient to carry out treatment (e.g. to remove wax in order to facilitate the assessment). However, if you need to have a procedure such as MRI carried out to explore a medical condition, ACC would not normally fund this.

(3) The assessment must be impartial

Your assessment needs to be impartial. This means you should ensure your evaluation of the patient and weighing up of the findings are based on a sound clinical approach and methodical analysis. In doing this, you are putting aside an advocacy role for either the client or ACC in order to give an objective assessment.

(4) It is not appropriate to conduct an assessment where there is a perceived conflict of interest

The report you provide influences both ACC cover and entitlement for occupational noise-induced hearing loss. Considerable expert and impartial clinical judgement and synthesis of information are expected of you. Conflicts of interest arise where the outcome of the assessment may be *perceived as significant for the doctor as well as the patient*.

It would not be appropriate to undertake the assessment if:

- you have a relationship with the patient through family, business or social links
- you, or a family member or close associate (or your/their beneficial entity⁷), have a controlling or significant interest in the provision of hearing aids, hearing rehabilitation or other services likely to be affected by ACC cover or entitlement decisions.

Situations	Conflict of interest	Possible action
You are asked to complete an occupational NIHL assessment on a patient who is a family friend/relative/close business associate.	Potential conflict of interest	Decline the assessment request, or at the very least Declare your conflict
You (or your family’s beneficial entity) have a financial interest in the company that leases rooms to an audiologist but no “interest” in the audiologist’s business i.e. a commercial arm’s-length transaction.	Probably not a conflict of interest or <i>can be managed</i> so as not to be a conflict of interest	Ensure you have guidelines in place (e.g. fair ways of letting clients know about other audiology practices in the area) so the audiology practice does not receive undue advantage through its association with you
You (or your family’s beneficial entity) have income, shares or directorship in an audiology service that provides hearing aids.	Clear conflict of interest	Decline the assessment request, or Declare your conflict, and Refrain from preferentially referring clients to any service in which you have a commercial interest

⁷ Trust or company

If you think there *may* be a conflict of interest:

- inform the patient that you cannot proceed.

Or, if you consider that, despite a perceived conflict, you do not have any personal interest in whether the patient has or has not a diagnosis of ONIHL:

- declare the conflict of interest on the assessment, and:
 - confirm that you remain impartial to the outcome
 - indicate how you manage the conflict of interest.

(5) Status of your opinion

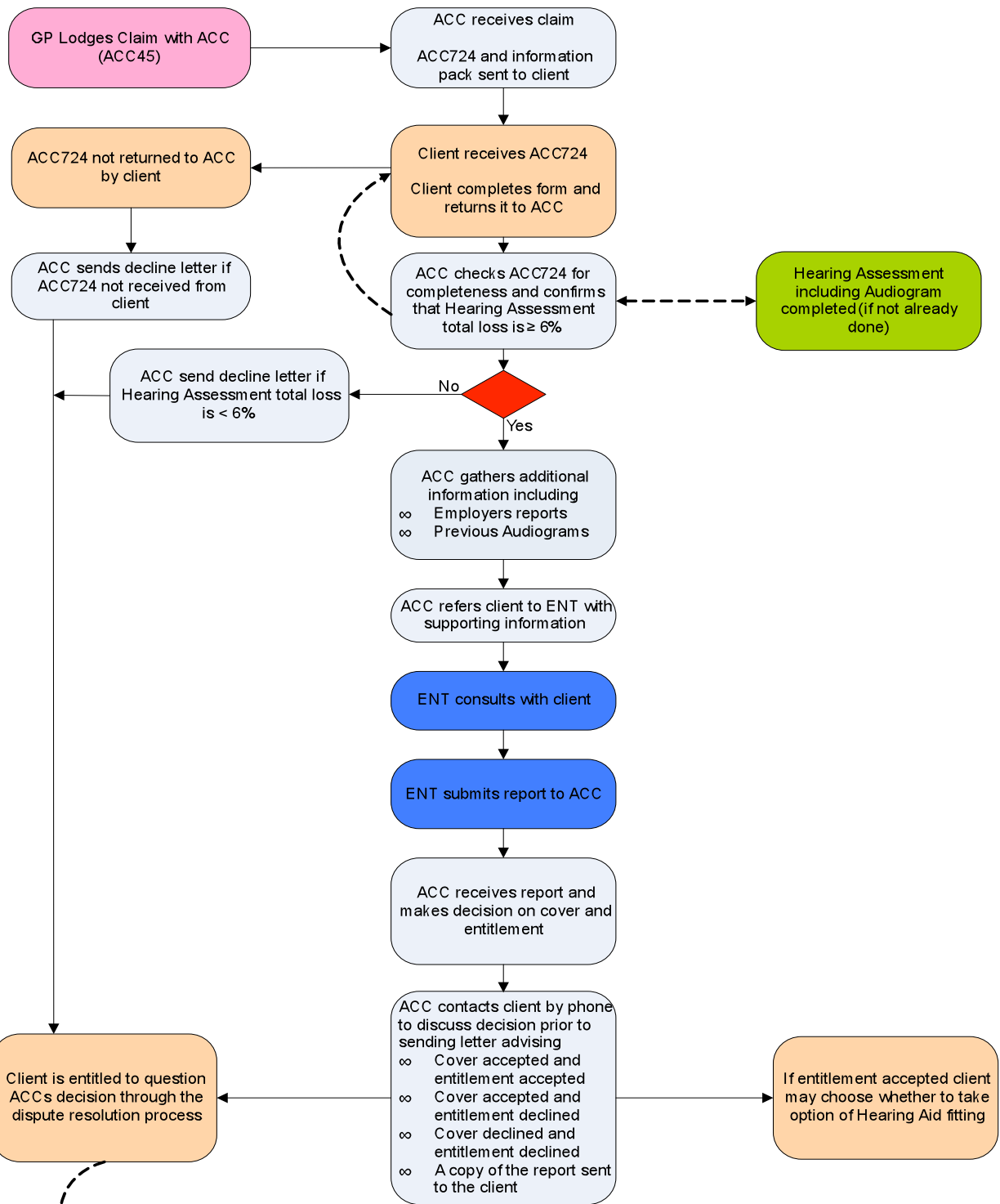
Your role is to assess the gathered information, including objective and clinical findings in the light of your professional knowledge in order to reach an opinion. You are not required to make a decision on the claim but your opinion will be taken into account by ACC in its decision making.

Requirement for a further audiogram during ORL hearing loss assessment

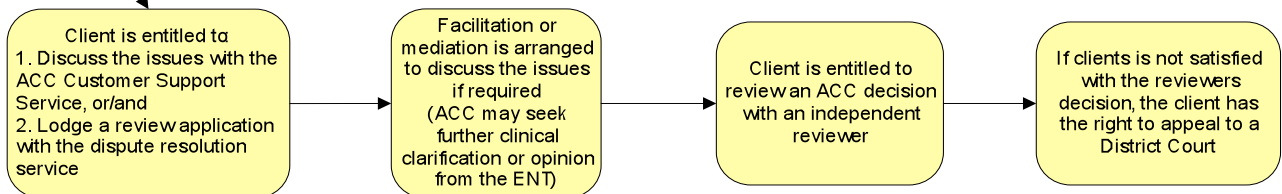
By and large an audiogram at or close to the date of ORL hearing loss assessment may be regarded as best practice. Acceptability of an older audiogram is ultimately at the discretion of the ORL carrying out the assessment, but the following points may be kept in mind:

- Where the client has long since ceased noise exposure an older audiogram (say six months or more) may well be perfectly adequate. Old audiograms from around the time the client ceased work may be useful for tracking the progression of a client's hearing loss.
- Individuals working in ongoing noise should have a more up-to-date audiogram (eg. within three months).
- Where the most recent audiogram is inadequate (poor test conditions, incomplete, unreliable patient responses etc.) it will need to be repeated.
- A client with active non-occupational ear disease may well require contemporary audiometry, especially if there is a recent clinical event (eg. barotrauma, sudden deafness etc).
- Inconsistent previous audiograms (query non-organic loss) would benefit from contemporary audiometry.
- Where the age-adjusted loss is very close to the threshold for cover it may be prudent to have an independent contemporary audiogram.

Hearing Loss Claim Process



Dispute Resolution Process



SUBSEQUENT TO YOUR REPORT

ACC will send a copy of your report to the client with the letter accepting or declining cover and/or entitlement. If the client chooses to seek a review of a decision by ACC, then ACC would normally ask the assessing doctor for further details, if there are any remaining questions following the assessment report.

The client may seek a second opinion from another specialist, and ACC may also ask this specialist for further information. ACC would normally refer the second opinion back to the first assessor for comments.

It would normally not be necessary (nor desirable) for the assessor to attend the review hearing since this is a quasi-legal environment, and reports on the client's file will generally be taken at face value.

The review is carried out by a reviewer employed by Dispute Resolution Services Ltd, an independent company. The client may choose to appeal any review decision to the District Court in Wellington.

Rehabilitation and entitlements

Rehabilitation is defined by ACC as a process of supporting a person with an injury covered by ACC so that they can live an everyday life. An everyday life relates to establishing a person's independence to the maximum extent practicable, given their strengths and abilities following an injury. This is where the concepts of impairment, disability and handicap fit in. A discussion of the different terms and associated measures is presented in Appendix C.

ACC has developed a Rehabilitation Framework, which is a commitment to provide clients with an integrated continuum of services and support that help the client to achieve sustainable employment and/or sustainable life in the community. The aims are to promote independence, participation, and quality of life.

ACC determines a client's entitlement to hearing rehabilitation after receiving a professional assessment of the cause of their hearing loss. Depending on the client's needs, they may be entitled to one or more social rehabilitation options provided under the Accident Compensation Act 2001. The relevant options for hearing injury are:

- equipment (aids and appliances)
- training for independence.

In general, ACC has two options for providing hearing rehabilitation. ACC can:

- contribute to the cost of the support (e.g. the cost of equipment such as hearing aids, assistive devices)
- fund and arrange rehabilitation support (e.g. hearing therapy, tinnitus counselling).

Clients with accepted cover and entitlements will be sent information on the amount of financial assistance ACC and the Ministry of Health will contribute towards the cost of hearing aids and associated services. The client is then free to approach any audiology practice registered with ACC.

For clients with profound hearing loss (usually those with hearing loss from treatment injury, or major accidents), cochlear implantation (or a contribution to costs) may be considered.

If a client is declined cover and entitlements, they may be eligible for funding assistance towards hearing aids from other sources.

A summary of cross-government hearing assistance is given in *Your guide to help for hearing loss* at: <http://www.acc.co.nz/publications/index.htm?ssBrowseSubCategory=Hearing%20loss%20injuries>

Information about funding sources is also given at:

<http://www.audiology.org.nz/Public/HearingAidFunding.aspx>

<http://www.nfd.org.nz/?t=16>

Information about ACC regulations for clients is available at:

<http://www.acc.co.nz/news/WPC089879>

Lists of public and private audiology services are provided at:

<http://www.audiology.org.nz/Public/FindAnAudiologist.aspx>

EVIDENCE REVIEWS

As part of the project to develop this Guide, ACC commissioned a series of evidence reviews to summarise the current state of knowledge in a range of related areas. Each literature review was peer reviewed by several international experts.

The reviews commissioned comprise:

Guideline for diagnosing occupational noise-induced hearing loss

1. *Part 1: Noise effects and duration*

David McBride, University of Otago

This paper describes the development of the international standards which summarise epidemiological data on hearing loss and noise exposure. It also includes information on types of noise, their effect on hearing loss, and typical noise exposures.

2. *Part 2: Epidemiological review: some risk factors of hearing loss*

Zhi-ling Zhang, ACC

This review covers risks of developing hearing loss associated with agents other than noise.

3. *Part 3: Audiometric standards*

Suzanne Purdy, University of Auckland, and Warwick Williams, National Acoustic Laboratories, Sydney, Australia

This review covers appropriate standards for carrying out audiometric assessments in terms of key issues such as test conditions, test equipment and tester qualifications.

A summary of each paper with recommendations follows.

Guideline for diagnosing occupational noise-induced hearing loss

Part 1: Noise effects and duration

David McBride, Occupational Medicine Specialist, University of Otago

The basic principle in diagnosis and assessment is that there must be a “suitable and sufficient” history of noise exposure to cause the degree of hearing loss at hand; although the audiometric notch is a sign of ONIHL, it is not pathognomonic.

Fundamental to the assessment procedure is knowledge of the quantitative relationship between noise and hearing loss, and how age and noise interact: one must know the degree of hearing loss that would be expected from noise exposure to a given level and duration – the noise “dose”. Noise-induced hearing loss may develop from both occupational and non-occupational sources, but these need to be distinguished because of the requirements imposed by ACC’s legislation.

In this guideline the relationships between noise exposure (level and duration) and hearing loss have been looked at with regard to the two main types of noise – continuous noise and impulse noise.

Continuous noise

Continuous noise has been examined in large cross-sectional studies carried out in Europe and the United States in the 1960s, with subjects who had been exposed to the same level of steady noise throughout their careers without the use of hearing protection. This allowed mathematical modelling of the relationship between noise and hearing level, shown to conform (within constraints) to an “equal energy theory”, equal amounts of “A-weighted” sound energy causing equal amounts of hearing loss.

The model was refined, and has been incorporated into the International Standard ISO 1999, which allows the calculation of the hearing loss to be expected from any given noise exposure in a range of percentiles of the population from the 5% least sensitive to the 5% most sensitive to its effects. Age has also been incorporated into the model, the two effects being combined in the populations actually under study, but allowed to be additive in their effects. The model does suffer from a number of assumptions and constraints, and is therefore not perfect, but at present is the best available for the purpose.

Recommendation: In order to make the diagnosis of noise-induced hearing loss, the level and duration of noise should be elicited (actual noise level data from the employer, or estimates). The noise estimates should then be used to predict the range of hearing impairment that might be expected from such noise exposure, referring to tables derived from ISO 1999. The client’s hearing should then be compared with these levels and also with the amount of hearing loss to be expected from age alone. This will allow assessment of the probability of causation.

Impulse noise

Impulse noise has been even more difficult to study. As the cumulative exposure dose is almost impossible to ascertain over a period of time, the human studies have relied on a temporary effect on the ear, temporary threshold shift (TTS), to evaluate probable long-term effects on hearing. There is much ongoing debate about the relationship between permanent hearing loss and TTS, but studies have shown that equal noise energy causes equivalent amounts of TTS (a corollary to the equal energy hypothesis). In the absence of further insights, there are “energy measures”, including A and B duration of an impulse, that allow the hazard to be estimated, albeit with less precision than for steady noise. There is also growing knowledge about C weighting as an energy measure.

Recommendation: Assessment of exposure to firearms is important. The type and calibre of weapon need to be known, along with the number of rounds (or cartridges) fired on each occasion, and how often exposure takes place. Exposure of less than 100 rounds per year may not pose a significant risk to hearing. Individuals shooting more than 10 rounds on each occasion, with monthly exposure, may be exposed to another 2-3 dB(A) of noise in addition to their occupational exposure. The additional hearing loss (HL), depending on dose, may vary, on average, from around 3 to 9 dB HL.

Noise levels

Also examined is the noise exposure that is known about from epidemiological studies both in New Zealand and from abroad. Most noise in New Zealand probably lies in the range of 85-90 dB(A), with some industries having noise exposures up to 100 dBA and a very few occupations being exposed in excess of this level.

Effect of hearing protectors

The noise dose is moderated by noise control measures in the workplace. Although noise management should focus on reduction of the noise at source, there is heavy reliance on hearing protection. For behavioural and other reasons, this is often much less effective than supposed, often reducing the noise exposure by much less than the 20-30 dB values often quoted and sometimes in the region of only 2-3 dB(A).

Recommendation:

- The type of hearing protection (type of plug and grade or class of earmuff) should be elicited.
- It is essential to form a clear idea of how often hearing protection has been worn.
- The highest grade earmuffs will have an assumed protective factor of up to 30 dB. However, to be effective, hearing protectors must be worn at all times when noise is present; otherwise their effectiveness is greatly reduced. The resulting protection can be as low as 2-3 dB.

Non-occupational factors impacting on hearing

Noise occurs not only at work, but also at home and at leisure. From the information available, it seems that the average person with a noisy job would have little extra material noise exposure added by leisure noise. However, perhaps 10-20% of people do have material exposure to non-occupational noise.

Recommendation:

- Firearms and shooting are probably the most hazardous types of exposure, and the frequency and intensity of such exposure must be evaluated (see Impulse noise section above).
- Exposure to music, both live and through music systems, may be hazardous for the few that listen for long periods at excessive levels.
- Regular attendance at nightclubs (i.e. weekly or more) poses a risk to hearing.
- People listening to personal music players may be at risk if exposure to excessive levels exceeds seven hours per week.

Lastly, other important factors in the assessment of hearing loss are mentioned, including best practice and guidance in the use of questionnaires (both self-completed and clinician-led) to elicit a full noise and otological history.

Guideline for diagnosing occupational noise-induced hearing loss

Part 2: Epidemiological review: some risk factors of hearing loss

Zhi-ling Zhang, Senior Research Adviser, ACC

Noise is the most important risk factor for occupational hearing loss at present. However, exposure to other risk factors (e.g. solvents and smoking) should not be ignored.

Age

Evidence that supports a synergistic effect of ageing and noise exposure appears to be very weak. Compared with those without historical noise exposure, older adults previously exposed to occupational noise do not have a higher rate of threshold changes and may even have a lower rate of the changes. These findings support the conclusion that noise exposure in working age is very unlikely to be an attribute of hearing deterioration in older people who are no longer exposed to noise. In other words, previous noise exposure is very unlikely to cause older people to be more prone to age-related hearing loss, even though hearing loss caused by the previous noise exposure will still exist.

An additive effect model of ageing and noise exposure on hearing loss is much more acceptable than the assumption of synergistic effect. Nevertheless, the model is not always in agreement with some data from available studies. An additive effect model with modification is considered to be the best approach available.

Recommendation: The impact of ageing has to be considered in the diagnosis of noise-induced hearing loss. Hearing deterioration (threshold changes) after people leave occupational noise exposure cannot be attributed to occupational noise exposure.

Exit audiograms (for those leaving employment or a noise-exposed job) appear to be critical in assessing the maximum amount of occupation-attributable hearing loss in the individual. However, any historical records of hearing tests can be relevant and helpful and should be tracked and considered for hearing impairment assessment.

When assessing older patients with significant hearing impairment and historically exposed to a high level of occupational noise, caution is needed to avoid potential “over-adjustment” of age-related hearing loss, especially in the cases where historical records of hearing tests are not available.

In terms of research on noise-induced hearing loss, age should be considered an important confounder and needs to be adjusted or controlled for.

Genetic factors

Genetic studies on *interactions with* noise-induced hearing loss appear to be at an early stage. The number of studies on individual genes or single nucleotide polymorphisms (SNPs) is still limited. Six of the 10 studies found are based on two sample sets, in Sweden and Poland.

It is noted that some genetic mutations are associated with susceptibility to noise-induced hearing loss. However, some of these findings are based on relatively large numbers of the genetic markers (e.g. SNPs) analysed. It is possible that some of the findings are false positive associations rather than true associations. Further studies are needed to test these associations in different sample sets so that true associations can be established.

Based on the odds ratios reported in these studies, and the sampling methodology used (e.g. the most susceptible versus most resistant), available studies appear to suggest that genetic markers *currently investigated* are not strong risk factors for noise-induced hearing loss. The contribution of genetic

factors to noise-induced hearing loss is also dependent on the frequency of related genetic markers in the local population, which appears to be unclear at this stage.

Potential *combination effects* of different related genes currently remain unexplored. The studies included in this review investigate only the effect of individual genes.

Recommendation: Applications of the results from the few available genetic studies on interactions with noise-induced hearing loss to diagnosis and management of people exposed to noise appear at this stage to be limited. Clinical applications have not yet been developed.

Organic solvents

Based on the studies reviewed, exposure to solvents appears to be a risk factor for hearing impairment. Styrene at relatively low exposure levels is associated with hearing impairment in the workplace at a low level of noise exposure. Some studies found that there was a potential synergistic effect of combined exposure to solvents (styrene and toluene) and noise. The effect indicates that the combined noise and solvent exposure could potentially lead to a greater risk of hearing loss than exposure to solvents and to noise alone. According to available studies, some solvents are associated with hearing impairments at lower (0.5, 1 and 2 kHz, for toluene and carbon disulphide) or high frequencies (6-8 kHz, for styrene), which are not typically seen in noise-induced hearing loss among working-age people.

However, most of these study results are based on cross-sectional study design. More cohort studies are obviously needed to further demonstrate and quantify the causal relationship between solvent exposure and hearing loss. The relationship appears to be relevant to clinical assessment.

Recommendation: Currently there is a lack of clinical tools or guidelines to assess hearing impairment in association with solvent exposure in the workplace. Surveillance data from hearing tests in the workers exposed to solvents could potentially be critical in the assessment.

Information on solvent exposure needs to be collected in hearing loss assessments, especially for workers from related industries, for example yacht building. Input from occupational health professionals may be needed in some cases. Risk control to reduce solvent exposure may need to be considered in the programmes to prevent noise-induced hearing loss in the workplace.

It is worth mentioning that some of these solvents are also present in cases of substance abuse (e.g. inhalation of solvent-based propellants). Cases of hearing loss caused by substance abuse have been reported previously. Related information and medical history need to be asked and considered in hearing loss assessment. Internationally, there is an absence of guidelines or criteria to determine solvent-related hearing loss at this stage.

Carbon monoxide

The findings from animal studies and human case reports are different. No hearing impairment was found in animal studies even with significantly high concentration exposure to carbon monoxide (up to 1,500 ppm). However, human cases of hearing loss were reported after carbon monoxide poisoning. Exposure levels of carbon monoxide are not available in the accidental poisoning reports. It is reasonable to assume that the poisoning levels are higher than the exposure levels in most workplaces.

Based on the case reports, carbon monoxide poisoning-related hearing loss could be described as bilateral sensorineural impairment and is at least partly reversible. It is unclear whether the hearing loss is related to potential ototoxicity and/or neurotoxicity of carbon monoxide.

There is only a very limited number of epidemiological studies on the link between occupational exposure to carbon monoxide and hearing impairment in the working-age population. More studies are needed in the future. Both the risk of hearing loss in association with long-term occupational exposure to carbon monoxide in the working environment and the possible interaction between the exposure, noise and other risk factors remain unclear at this stage.

Recommendation: A patient's medical history of carbon monoxide poisoning should be investigated and recorded during the diagnosis of noise-induced hearing loss. Audiometric testing results (if available) following the poisoning need to be considered in the assessment.

Smoking

Smoking can be considered a risk factor of hearing loss. However, all reviewed studies have significant weaknesses in methodology, especially in the measurement of noise exposure and in controlling for the exposure as a relevant confounder. Even though most of the included studies indicate that smoking is associated with hearing loss, more well-designed studies with appropriate controls on relevant confounders are needed.

Recommendation: Patients with noise-induced hearing loss can be advised to stop smoking to prevent related adverse health effects including possible further hearing impairment. In some studies reviewed, ex-smokers had either a lower risk of hearing impairment than current smokers or an insignificant risk when compared with non-smokers. For long-term heavy smokers, it is possible that smoking could contribute to hearing loss.

Applications of evidence to hearing assessment

It is relatively difficult to use these findings for clinical assessment of individual patients. Effects of the risk factors are assessed at population or group level in epidemiological studies, so there are limitations in generalising the findings for an individual. Moreover, the exposure "dose" of the risk factors (apart from age) for an individual is usually unclear and difficult to obtain quantitatively. Exposure to multiple risk factors also makes the decision making more difficult. As mentioned previously, there is also a lack of high quality cohort studies for some risk factors reviewed.

Internationally, there is an absence of clinical tools to quantitatively determine how much of an individual's hearing loss is caused by smoking and/or solvents.

However, these limitations do not hinder the findings being used in a "qualitative approach" in a clinical assessment. For example, if hearing impairment in a yacht-building worker does not match the level of noise exposed, information in relation to other risk factors (e.g. exposure to styrene, smoking and other non-occupation-related exposure) should be considered when interpreting the hearing impairment. In these cases, historic audiometric records are particularly valuable.

It will be a rare case where the apportionment is materially affected by these factors, given the current state of knowledge. If substantial exposure has occurred, a separate ACC claim for gradual process injury might be expected.

Guideline for diagnosing occupational noise-induced hearing loss

Part 3: Audiometric standards

Suzanne Purdy, University of Auckland, and

Warwick Williams, National Acoustic Laboratories, Sydney, Australia

This document considers standards relating to audiometric assessment of clients presenting with a history of noise exposure.

Acoustical test environment

Maximum permissible ambient sound pressure levels or noise levels (MPANL) in the test area should meet the requirements of ISO 8253-1 Acoustics – Audiometric test methods, Part 1: Basic pure-tone air and bone conduction threshold audiometry for hearing threshold levels down to 0 dB HL.

The ability to accurately determine bone conduction thresholds to a hearing level of 5 dB HL is required. The maximum permissible background sound pressure levels to test to threshold levels of 5 dB for air and bone conduction with a +5 dB uncertainty over the range 500-8,000 Hz are provided in the table below. All test environments used for diagnostic audiology should meet the ambient noise requirements for bone conduction testing and hence test environments should comply with the ambient noise levels specified in the right-hand column in the table.

Maximum permissible ambient noise levels ($L_{S,max}$ for air and bone conduction audiometry for hearing thresholds to 5 dB, with 5 dB uncertainty over the range 500-8,000 Hz, using typical supra-aural earphones such as the Telephonics TDH39 with MX 41/AR cushions or the Beyer DT48 (adapted from ISO 8253-1 Table 2 and Table 4)

Octave band centre frequency (Hz)	Maximum permissible background sound pressure levels	
	$L_{S,max}$ (dB re 20 μ Pa)	
	Test tone frequency range (Hz)	
	Air conduction audiometry	Bone conduction audiometry
	500-8,000	500-8,000
125	55	34
250	46	24
500	31	21
1,000	33	20
2,000	40	19
4,000	47	15
8,000	46	22

Calibration

Audiometers should be of Type 1, as specified by IEC 60645-1. Formal calibration of all audiometric test equipment should be carried out on an annual basis for equipment that moves between testing locations or biennially for equipment kept in a fixed testing location. Calibration should be undertaken by an accredited testing laboratory with full, documented traceability to National Standards. Formal calibration should be carried out in accordance with the relevant ISO and IEC standards (IEC 60318, IEC 60645 and ISO 389). Daily listening checks are very important. A brief listening check should be carried out on a daily basis.

Training and qualifications of person undertaking audiometry

The current guidelines pertain to diagnostic audiometry for the purpose of diagnosing NIHL, and hence the person undertaking audiometry requires a high level of training and skill. Audiologists have the highest level of training and so are the preferred professionals for audiometric testing.

Audiometric test procedures

Rather than leaving earphones in place during bone conduction testing, it is preferable that testers use audiometric testing facilities that allow accurate bone conduction audiometry down to at least 5 dB HL without the test ear being occluded.

Immittance audiometry (tympanometry and acoustic reflex testing) is recommended as a cross-check procedure for pure-tone audiometry to determine if there is a conductive component to the hearing loss.

Because of the errors that potentially can affect air and bone conduction thresholds, and the possibility of incorrectly identifying middle ear pathology using tympanometry alone (without acoustic reflexes), speech audiometry and acoustic reflex testing are recommended as core elements of the diagnostic audiometry test battery.

Other research

In addition to the evidence reviews, several major bodies of research on hearing loss were commissioned by ACC in conjunction with the Health Research Council. Some papers have already been published from these research projects, and others are anticipated. The projects, and the researchers involved, are:

- ***Occurrence of NIHL in New Zealand***
School of Population Health, University of Auckland
Lead researchers:
Peter Thorne
David Welch
Gareth John

- ***Prevention of occupational noise-induced hearing loss in New Zealand***
Centre for Ergonomics, Occupational Safety and Health, Massey University
Lead researcher:
Ian Laird

An earlier report on best practice for management and prevention of occupational noise-induced hearing loss was commissioned by ACC from the University of Auckland and is available at:
http://www.acc.co.nz/PRD_EXT_CSMP/idcplg?IdcService=GET_FILE&dID=4620&dDocName=WIM2_065096&allowInterrupt=1

COMPLETING AN ASSESSMENT

Your report should be on the ACC723 form (see Appendix A), which is available for either manual or electronic use, or using the same headings and order as form ACC723. The assessment report should be sent to ACC in the knowledge that the report will be provided to the client on request.

(1) Previous treatment and rehabilitation

This section is the place to record any information ACC has sent you, or you have yourself unearthed about:

- the client's earlier claim/s relating to hearing loss
- previous ENT assessment/s and/or treatment
- historical audiometric information.

If you have new information available, you should send a copy with your report. If you find in the course of your assessment that further information may be available (e.g. copies of previous audiograms or measures of occupational noise levels), please forward this information to ACC.

(2) History

This section is for recording the client's history – incorporating information from both the client's completed form ACC724 (see Appendix B) and your own verbal history. It is expected that you will ask questions based on information provided on form ACC724 so that you can identify relevant noise exposure levels and any other aspects of the client's history that may have contributed to the hearing loss.

The first section asks for a summary of the client's history, outlining salient points. From there, further detail is requested relating to different aspects of noise exposure.

Occupational noise exposure

This is of paramount importance in providing an evidence-based opinion. In all cases other than the most obvious, it is essential to extract details of the client's work environment to enable you to establish the probable exposure levels.

Based on the questionnaire, together with your verbal history and other sources, you are asked to identify whether there is a history consistent with exposure to hazardous levels of noise within New Zealand. ACC does not cover occupational noise-induced hearing loss developed outside New Zealand (see Relevant Legislation section, p4).

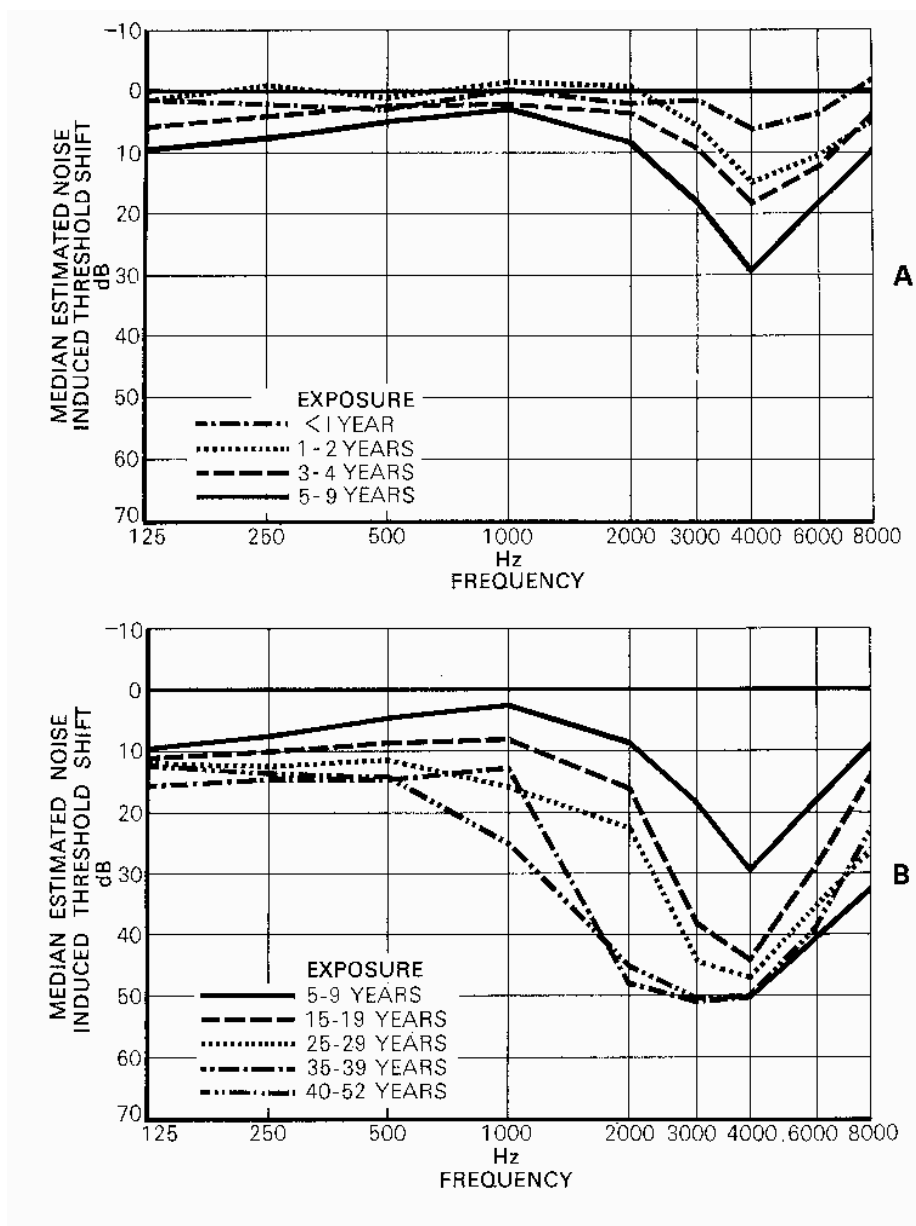
You should specify the period when, and the location where, relevant exposure occurred, and whether or not there is likely to have been adequate hearing protection used, including the proportion of the time such protection was used. This will lead to a summary of the duration and probable equivalent intensity level of total exposure the client is likely to have experienced.

ACC staff will have sought information relating to work records of hearing loss and/or noise levels, and forwarded those found to you. Many employers, particularly employers of large workforces, have very detailed information available. If there is insufficient information available, and you suspect that more information may be able to be located, any effort you or your staff can put into locating such information, or requesting that ACC do so, may provide more solid evidence to underpin your opinion.

Note the date of onset of auditory symptoms, and refer to information, where available, about the development of hearing loss, noting that the rate of increase of NIHL at specific frequencies (e.g.

4,000 Hz) typically decelerates after 10 years' exposure (see Figure 1). In other pathologies, hearing loss at individual frequencies may accelerate, which is frequently the case in age-related hearing loss.

Figure 1. Audiograms showing onset and progression of NIHL in female jute weavers⁸ exposed to noise levels averaging 100 dB(A)



However, because of the built-in low fence of the PLH scale, together with the spread of hearing loss from 4,000 Hz to lower frequencies, which are weighted more highly in the PLH scale, the development of percentage hearing loss with years of exposure tends to be linear – see Figure 2, which is derived from the data in Figure 1.

⁸ Taylor W, et al. Study of noise and hearing in jute weaving. *Journal of the Acoustical Society of America* 1965;38:113

Figure 2. Progression of hearing loss, expressed as a percentage, as a function of years of exposure for female jute weavers as in Figure 1 – linear trend line superimposed

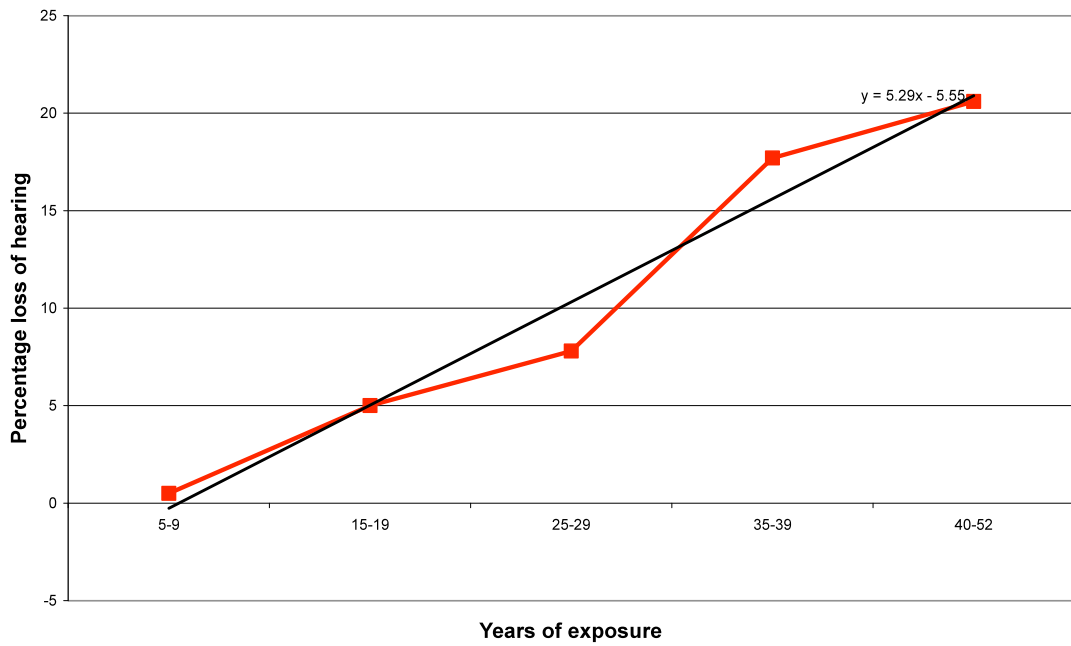
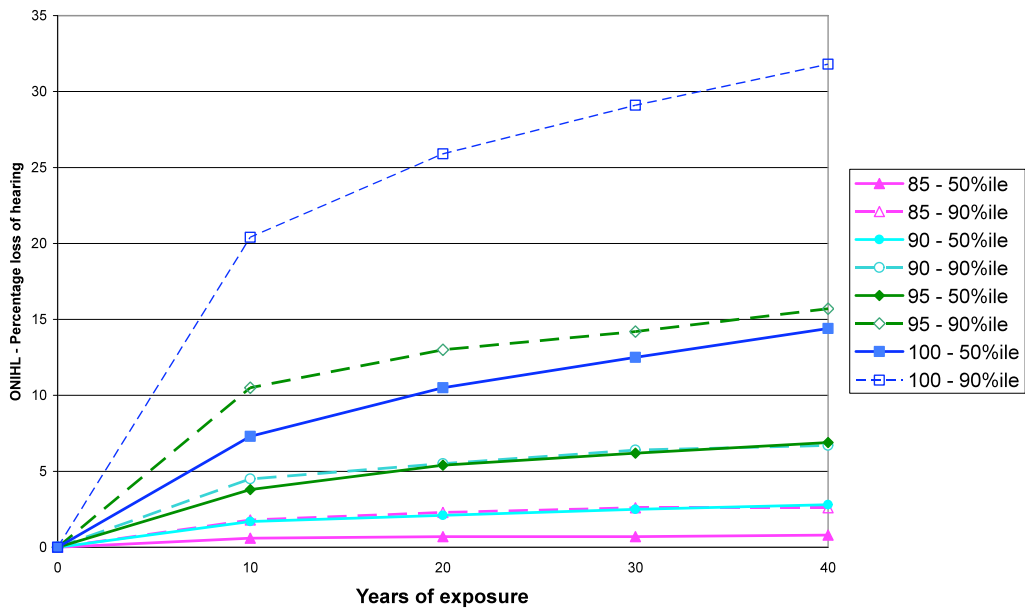


Figure 3 shows a similar pattern for grouped data for men (taken from thresholds derived from ISO 1999 – see Appendix G).

Figure 3. Progression of hearing loss, expressed as a percentage, as a function of years of exposure at various noise levels for mean data for 60-year-old men with standard age adjustments, calculated from ISO 1999 (see Appendix G)



Useful resources in completing this section are:

- David McBride's evidence review of the types of noise (steady-state or impact/impulse) and their effects on hearing⁹
- the University of Auckland report on prevention of hearing loss¹⁰
- Department of Health historical noise levels¹¹
- various other databases of noise levels
- papers on specific industries such as metal manufacturing¹², farming¹³, and sheep shearing¹⁴.

Information on the impact of hearing protection is given in:

- David McBride's evidence review of the types of noise and their effects on hearing⁹
- the University of Auckland report on prevention of hearing loss¹⁰.

Military noise exposure

If the client has a history of involvement with the armed forces, you are asked to comment on the role the person played, and their status, that is, unpaid such as Cadets, or, if regular forces, which one and in what role and environment. In particular you should focus on the exposure to noise – the types of noise and the duration of any exposure.

Information about impulse noise and firearms in particular is given by McBride⁹. Questions to the client should include whether there were auditory symptoms at the time, whether help was sought for hearing problems, and if any records exist. The armed forces are an invaluable source of audiometric records, so if these exist they should be accessed.

Non-work-related noise exposure

You are asked to comment on any significant exposure to non-work-related noise. Details should be recorded. If there is significant exposure to non-occupational noise, you may need to consider reducing the apportionment of the hearing loss to ONIHL accordingly. Information about typical recreational noise encountered in New Zealand is given by McBride⁹.

Head injury or traumatic ear injury

Is there a history of head injury or trauma to the ear/s that is a contributing factor in the current levels of hearing loss? To be considered, the injury should have resulted in noticeable hearing symptoms at the time. Normally, medical records of the injury would be expected to exist.

⁹ Guideline for diagnosing occupational noise-induced hearing loss. Part 1: McBride D. Noise effects and duration. Report for ACC, November 2010

¹⁰ Thorne PR. Best practice in noise-induced hearing loss management and prevention: a review of literature, practices and policies for the New Zealand context. Auckland UniServices, November 2006
http://www.acc.co.nz/PRD_EXT_CSMP/idcplg?IdcService=GET_FILE&dID=4620&dDocName=WIM2_065096&allowInterrupt=1

¹¹ Department of Health. Summary of noise surveys, 1986

¹² Welch D, et al. Report on noise and hearing loss in the metal manufacturing industry. Prepared for the Accident Compensation Corporation. Auckland UniServices, December 2009

¹³ McBride D, Firth H, Herbison G. Noise exposure and hearing loss in agriculture: a survey of farmers and farm workers in the Southland region of New Zealand. *Journal of Occupational and Environmental Medicine* 2003;45:1281-1288

¹⁴ Acoustics Research Group, University of Canterbury. Noise of sheep shearing systems, Parts 1 and 2, February 2010

If there is a significant history of trauma, please specify details (including whether an ACC claim was lodged, and sources of further information).

Family history

If there is any family history of hearing loss this should be described. Note that the absence of a family history does not exclude genetic hearing loss – in New Zealand, as elsewhere, non-syndromic sensorineural autosomal recessive deafness (NSRD) is the most common form of genetic hearing loss. Seventy-five percent of genetic types of hearing loss are related to recessive conditions. Most of these conditions relate to mitochondrial inheritance, and some are responsible for susceptibility to hearing loss under certain conditions (e.g. development of diabetes, exposure to aminoglycosides). Non-syndromic hearing loss is the most genetically heterogeneous trait known. Over 80 loci and 30 genes have been identified. An excellent summary of the current state of knowledge is presented at: ghr.nlm.nih.gov/condition/nonsyndromic-deafness

Ototoxicity

This is in two sections – exposure to ototoxic drugs, and exposure to chemicals in the workplace which may have an ototoxic or neurotoxic effect or may potentially interact with noise.

If there is a history of exposure to drugs that might have caused or contributed to hearing loss, this should be explored to identify the likelihood of contributing to the hearing loss.

OTOTOXIC DRUGS ¹⁵	
Aminoglycoside antibiotics ¹⁶	Particularly streptomycin, neomycin, kanamycin, gentamycin, vancomycin, tobramycin ¹⁷ . Note that there is genetic variation in susceptibility to aminoglycoside ototoxicity. There may be changes to vestibular function in addition to cochlear hearing loss. There is no safe dosage for these antibiotics.
Anti-neoplastics for cancer treatment	Particularly those containing platinum (e.g. cisplatin ¹⁸ , vinblastine, vincristine, carboplatin – 62% of people develop high frequency hearing loss, which is usually permanent). A recent paper has shown that children treated with cisplatin and who develop high frequency hearing loss are likely to show further deterioration in thresholds 10-15 years later. Drugs broad in application are more likely to be ototoxic than those with a narrow focus.
Salicylates	Aspirin – more than 12* 325mgm tablets/day can cause mild to moderate (usually flat) hearing loss, but effects may be reversible if treatment is discontinued ¹⁸ . May also have CNS effects.
Quinine ¹⁹	Effects multifactorial, primarily via vasoconstriction of the cochlear blood flow. Usually reversible, but on rare occasions permanent. As with salicylates, may also affect the CNS.
Loop diuretics	Ethacrynic acid and furosemide ²⁰ when given in large doses or in cases of renal failure can cause hearing loss. This may be reversible.

¹⁵ Roland P. Characteristics of systemic and topical agents implicated in toxicity of the middle and inner ear: review. *Ear, Nose and Throat Journal* January 2003;82(1) Supplement 1:2-8

¹⁶ Selimoglu E. Aminoglycoside-induced ototoxicity. *Current Pharmaceutical Design* 2007;13:119-126

¹⁷ Rybak LP, et al. Mechanisms of cisplatin-induced ototoxicity and prevention. *Hearing Research* 2007;226:157-167

¹⁸ Boettcher FA, Salvi RJ. Salicylate ototoxicity: review and synthesis. *American Journal of Otolaryngology* 1991;12:33-47

¹⁹ Shine NP, Coates H. Systemic ototoxicity: a review. *East African Medical Journal* 2005; 82:536-539

²⁰ Rybak LP. Ototoxicity of loop diuretics. *Otolaryngologic Clinics of North America* 1993;26:829-844

If there is a history consistent with exposure to other ototoxic agents that might have caused or contributed to hearing loss, this needs to be identified. Information about ototoxic agents in the workplace is given by Zhang²².

A review in 1997²³ concluded that “the data currently available indicate that at high levels of exposure, which of themselves are capable of tissue insult, interactions between noise and hazardous substances may occur. The information currently available, however, does not allow any conclusions to be drawn with respect to lower more occupationally relevant levels of exposure”.

CHEMICALS IN THE WORKPLACE AFFECTING HEARING	
Substances	Workplaces where these might be encountered
Organic solvents ²⁴	
Toluene	Manufacture of chemicals, paint and lacquers, pharmaceuticals, rubber products, fibreglass products, food containers, carpet; oil refining, aircraft operation, boat building
Styrene	
Xylene	
Dimethylformamide	Manufacture of clothing and textiles
Dinitrobenzene ²⁵	Dry cleaning Paint manufacture Manufacture of rubber items
Gases	
Carbon monoxide	Combustion; fuel gas mixtures; chemical manufacturing; mining and metal processing
Heavy metals	
Cadmium	Manufacture of alkaline batteries; manufacture of pigments, coatings, and platings; and plastics Construction, mining, manufacturing (batteries, ammunition); formerly paint, ceramics, pipes Fluorescent light bulbs, dental amalgam, solder, thermometers, detonators
Lead	
Mercury	

(3) Clinical examination

Please describe the results of your clinical examination (e.g. R ear, L ear, nasal function, hearing and balance if appropriate).

If your clinical examination identifies any factors that might cause or contribute to the client’s hearing loss, specify the findings, the possible causes and the most likely cause/s. Refer to David McBride’s²⁶ paper in completing this section.

(4) Hearing loss (ACC612)

If you have commissioned a new hearing loss assessment, please forward it to ACC with your report. See page 9 for a discussion of the conditions under which it might be appropriate to refer for another assessment.

Please specify the date of the audiometric results on which your report is based.

Please specify other tests that you believe are required, and the reasons for this. Note that if your investigation is for conditions that would not be covered by ACC, then ACC would not pay for it.

²² Guideline for diagnosing occupational noise-induced hearing loss. Part 2: Zhang Z. Epidemiological review: some risk factors of hearing loss. Report for ACC, November 2010

²³ Cary R, Clarke S, Delic J. Effects of combined exposure to noise and toxic substances – critical review of the literature. *Annals of Occupational Hygiene* 1997;41:455-465

²⁴ Śliwiska-Kowalska M. Exposure to organic solvent mixture and hearing loss: literature overview. *International Journal of Occupational Medicine and Environmental Health* 2007;20:309-314

²⁵ <http://www.osha.gov/SLTC/healthguidelines/dinitrobenzeneallisomers/recognition.html>

²⁶ Guideline for diagnosing occupational noise-induced hearing loss. Part 1: McBride D. Noise effects and duration. Report for ACC, November 2010

(5) Summary and recommendations

Summary of hearing loss

Is the pattern of hearing loss typical of NIHL?

If you believe this is work-related noise-induced hearing loss – but the pattern is not consistent with the “Distinguishing features of occupational noise induced hearing loss”²⁷ (see Appendix F) please explain your reasons.

Comment on any asymmetry in the audiogram. Note that some asymmetry in the frequencies normally affected by noise may be associated with firearm use, with worse hearing expected in the ear *opposite* to the side on which rifles were shouldered²⁸. Where this is not the case, you may need to investigate further, or include this component of the hearing loss in the percentage attributed to “other causes”. Where there is a significant asymmetry, some cause other than occupational noise exposure would normally be expected, unless there is clear evidence of consistent unilateral exposure in the workplace (very rare because of reverberation, apart from shooting and headphone use).

Apportionment of causes

In this section, you are asked to apportion the percentage hearing loss for each relevant possible cause – occupational noise-induced hearing loss, presbycusis and other factors.

Information about the percentage loss of hearing scale used in ACC’s hearing regulations is provided in a paper by Greville²⁹, and the National Acoustic Laboratories supply a spreadsheet to facilitate calculations, which can be ordered from: http://www.nal.gov.au/nal-software_tab_percentage-loss.shtml

A key resource for carrying out apportionment is the British Guideline on the diagnosis of noise-induced hearing loss for medico-legal purposes³⁰, to which you are strongly advised to refer, and which is reprinted in Appendix E.

The three main requirements they identify are:

- high frequency hearing loss, *in the presence of*
- a potentially hazardous amount of noise exposure, *and*
- an identifiable high frequency audiometric notch or bulge.

As can be seen in Figure 1, it is expected that in the early years of exposure to occupational noise, a symmetrical notch at around 4 kHz will typically be observed, but as the person ages, a “bulge” affecting lower frequencies (typically down to 2 kHz) appears.

In addition, four other factors need to be considered:

- the clinical picture
- compatibility of the degree of observed hearing loss with population data on hearing loss associated with age and the probable level and duration of noise exposure (see Figures 3 and 4, and Appendix G)
- if the diagnosis of NIHL is borderline, whether another alternative or additional diagnosis is appropriate
- complicated cases such as asymmetrical or conductive hearing loss. In the latter case, bone conduction thresholds may be used (with allowance for known interactions between conductive and cochlear conditions). The paper by Purdy and Williams³¹ discusses issues such as bone conduction reliability.

²⁷ American College of Occupational and Environmental Medicine Noise and Hearing Conservation Committee. Noise-induced hearing loss, 2002

²⁸ Prosser S, Tartari M, Arslan E. Hearing loss in sports hunters exposed to occupational noise. *British Journal of Audiology* 1988;22:85-91

²⁹ Greville A. The NAL percentage loss of hearing scale. ACC, February 2010

³⁰ Coles R, Lutman M, Buffin J. Guidelines on the diagnosis of noise-induced hearing loss for medicolegal purposes. *Clinical Otolaryngology* 2000;25:264-273

³¹ Guideline for diagnosing occupational noise-induced hearing loss. Part 3: Purdy S, Williams W. Audiometric standards. Report for ACC, November 2010

The age-related percentage hearing loss (where the client is over 55 years for men or 68 years for women) should come from the age corrections defined in the regulations. It is acknowledged that individual susceptibility to presbycusis may vary widely. Refer to ISO 7029 for guidance (see Appendix E). If you do not use the corrections defined under the regulations, you must explain why you have chosen not to do so. Any such recommendation would be subject to peer review.

Where other factors exist, you should identify the percentage you attribute to them, and explain which factors, in your opinion, contribute to the hearing loss in the summary section, but you are not required to *quantify* their relative contribution if there is more than one.

The remaining hearing loss is therefore the percentage binaural loss attributed to occupational NIHL. Note that non-occupational NIHL should be included in the “other factors” apportionment.

Useful additional resources in making this apportionment include:

- McBride³²
- Dobie³³
- ISO 1999 – see sample calculations in Appendix G.

ISO 1999 provides statistical data on the effects of noise (and time) on a large population of workers. It cannot be used to make an accurate prediction of any individual’s hearing loss and, indeed, in the standard there is a warning not to do so. However, in the introduction it also states that “in doubtful individual cases, the data in this international standard might provide an additional means for estimating the most probable cause and audiological diagnosis”. Coles has stated that “the hearing impairments measured should be checked for compatibility with the client’s age, sex and estimated total amount of noise exposure, including military and non-occupational, using ... some appropriate source such as ISO 1999”. Dobie expresses the view that “the ISO model can be quite helpful in supporting (or undermining) a diagnosis of noise-induced hearing loss”.

In summary, ISO 1999 provides statistical data which can be helpful in assessing difficult cases. These data should not stand alone but should be considered along with all the other information relevant to the individual case.

The last requirement of this section of the assessment is to identify what, in your opinion, employer/s or job task/s within the New Zealand workplace are most likely to have caused or contributed to the client’s hearing loss.

Opinion

In this section, you should summarise your view of the case, where necessary explaining and providing justification for your apportionment between occupational NIHL and other causes. In simple cases, little justification will be necessary, but in more complex cases you should provide a full rationale.

You have been asked to give an expert opinion. Attribution and particularly quantification of causation is in essence an inexact science. Your opinion should be based on the balance of probabilities.

Remember that other opinions may be sought and it will be helpful if you have clearly identified how you have arrived at your opinion. Where conflicting opinions are presented, the final decision will be made on the basis of the quality of the supporting arguments.

Where there have been earlier claims for hearing loss, please describe your findings in the context of these.

If you think any other information or expert opinion would be beneficial in further assessment of this case, you should provide details. An example would be referral for investigation of asymmetrical hearing loss.

³² Guideline for diagnosing occupational noise-induced hearing loss. Part 1: McBride D. Noise effects and duration. Report for ACC, November 2010

³³ Dobie R. *Medical-Legal Evaluation of Hearing Loss*. 2nd edition. San Diego: Singular, 2001

You will be expected to provide the client with advice on prevention of further hearing loss, but it is not necessary to report on this.

Hearing rehabilitation

If the client's hearing loss attributed to occupational NIHL is 6% or more, you should indicate whether hearing aids should be considered binaurally or not. Binaural would be the default response. If binaural is not selected, please explain why.

Your reasons may be due to clinical causal issues, or to issues around the client's preference, environment or abilities (e.g. the client may have difficulties with manipulating small objects).

Comment on the client's need for, and/or motivation to use, rehabilitative devices. Most people with hearing loss are aware of hearing limitations for some time – estimates reported in the literature are between seven and 10 years – before they seek assistance in the form of hearing aids. Providing them with devices before they've reached a state of readiness may not be appropriate.

Please comment on whether the client wishes to trial hearing aids at this time.

If the client chooses not to trial hearing aids despite having a hearing loss from covered causes of at least 6%, they may contact ACC when circumstances change. Assuming the client has been approved for cover and entitlements, ACC would normally approve a current hearing assessment and then issue a decision on entitlements.

Declaration

If any conflict of interest exists (see page 8), please declare it, and describe any mitigating action you have taken.

CASES

A number of real cases from ACC's files follow. Because they are genuine cases, they do not necessarily include complete histories, nor, indeed, accurate apportionments. They are presented with comments included from expert reviewers, and it is hoped that they will be a useful starting point for discussion and development.

Example of ONIHL as primary cause of hearing loss: Case 1

History

55-year-old male who has noticed progressive hearing loss for about seven years. No complaint of tinnitus.

Past history

Nil of note.

Non-work noise

Nil of note.

Occupational history

Twenty-five years as a forestry worker with extensive use of chainsaws. Prior to this, seven years in a very noisy sawmill. Hearing protection worn for the last 15 years, but on detailed enquiry, not worn at all adequately until the last three years.

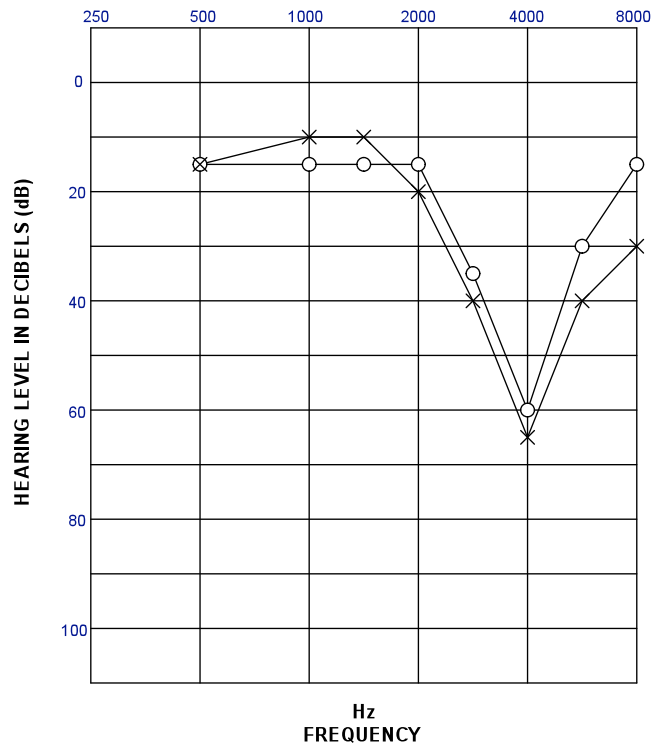
Examination

Normal tympanic membranes. Positive Rinne tests.

Audiogram

The features are:

- 6.8% total hearing loss (Right: 6.1%, Left: 8.4%)
- assessor's opinion: hearing loss consistent with occupational noise history
- no age adjustment necessary.



	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	15	15	15	15	35	60	30	15	6.1
Left	15	10	10	20	40	65	40	30	8.4
Binaural									6.8

Conclusion

Total hearing loss	6.8
Occupational NIHL apportionment	6.8

Comments

- There is a substantial history of noise exposure and a typically notched audiogram.
- The extent of the hearing loss is compatible with the noise history.
- There is no evidence of any other likely contributing cause of hearing loss.
- Any age effect is minimal (in terms of PLH), and the age is below that where an age correction is mandatory.
- It can be helpful to take a detailed history of the way that hearing protection is used, since it will frequently have little impact on the degree of ONIHL.

Example of ONIHL as primary cause of hearing loss: Case 2

History

54-year-old male, currently self-employed as a boat builder.

Past history

There was a history of ear infections associated with swimming in the past – but not for the last 15 years.

Non-work noise

No noisy hobbies, only noisy domestic activities such as lawn mowing.

Occupational history

Thirty-six years as a boat builder, specialising in work on super-yachts. Exposed to high levels of noise 8-10 hours per day. A large number of people (up to 170) working in the area; sometimes 25-30 people working on aluminium with power tools at the same time. No effective hearing protection in early days; even in more recent times, still noisy when earmuffs in place.

Last six years in management, but still working in noisy area with exposure exceeding eight hours per day. Hearing protection used, but not 100% of the time. Tinnitus for last 15 years.

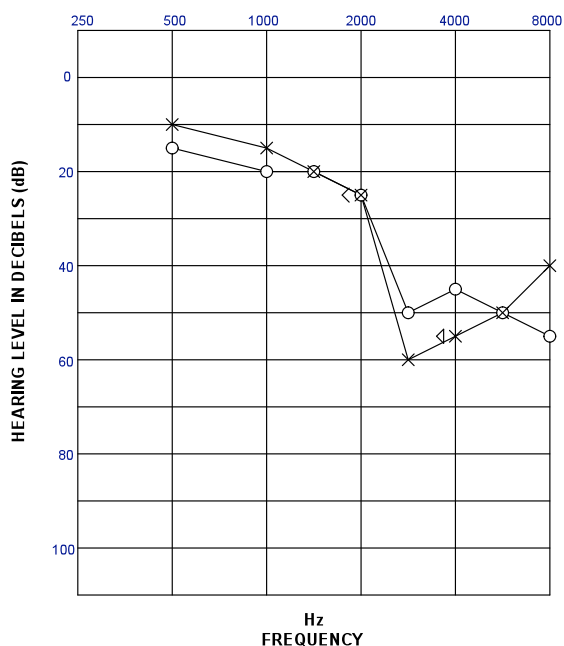
Examination

All normal.

Audiogram

See below. The features are:

- 11.0% total hearing loss (Right: 11.2%, Left: 12.6%)
- assessor's opinion: hearing loss consistent with occupational noise history
- no age adjustment necessary.



	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	15	20	20	25	50	45	50	55	11.2
Left	10	15	20	25	60	55	50	40	12.6
Binaural									11.0

Conclusion

Total hearing loss	11.0
Occupational NIHL apportionment	11.0

Comments

- There is a strong history consistent with ONIHL, and clearly the predominant factor in this case is ONIHL.
- Any age effect is minimal (in terms of PLH), and the age is below that where an age correction is mandatory.

Example of ONIHL from impact noise: Case 3

History

54-year old male, currently an earth-moving machinery operator.

Past history

None of note.

Non-work noise

No noisy hobbies, apart from occasional duck shooting in the 1970s.

Occupational history

Twenty-seven years as farrier blacksmith making horseshoes for 4-5 hours per working day, with no suitable hearing protection being worn. Most recently, 12 years as a bobcat driver with constant noise exposure, although hearing protection was worn at all times.

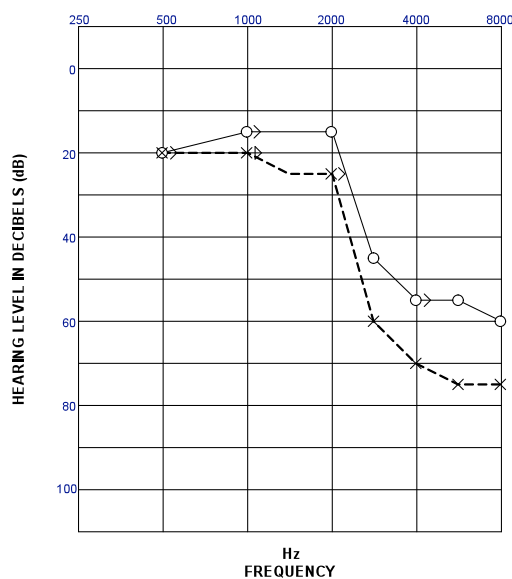
Examination

All normal.

Audiogram

The features are:

- bilateral sensorineural moderate notched hearing loss, worse on the left
- 12.0% total hearing loss (Right: 9.7%, Left: 18.0%)
- assessor's opinion: hearing loss consistent with occupational noise history, with greater hearing loss on the left attributed to higher level of impact noise exposure from blacksmithing work
- no age adjustment necessary.



	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	20	15	15	15	45	55	55	50	9.7
Left	20	20	25	25	60	70	75	75	18.0
Binaural									12.0

Conclusion

Total hearing loss	12.0%
Occupational NIHL apportionment	12.0%

Comments

- While the hearing loss is superficially consistent with his considerable occupational impact noise exposure, it is unusual not to have some recovery at 8 kHz at his age (54 years).
- The degree of asymmetry is unlikely to be fully explained by the head shadow effect although this is more of a factor with impact and impulse noise.
- No other factor was identified to explain the degree and configuration of hearing loss, and, specifically, the additional hearing loss on the left remains unexplained.
- A more reasonable apportionment for ONIHL would be 9.7% (i.e. based on the assumption that the hearing loss on the right reflects the binaural noise-induced component).

Example of age-related hearing loss only: Case 4

History

84-year-old male.

Past history

No history of head injury or ototoxic drugs. No family history of hearing loss. Difficulty hearing in the presence of background noise (but no indication given of how long this had been the case).

Non-work noise

Has mowed his own lawns and used power tools for hobby work, but using ear protection.

Occupational history

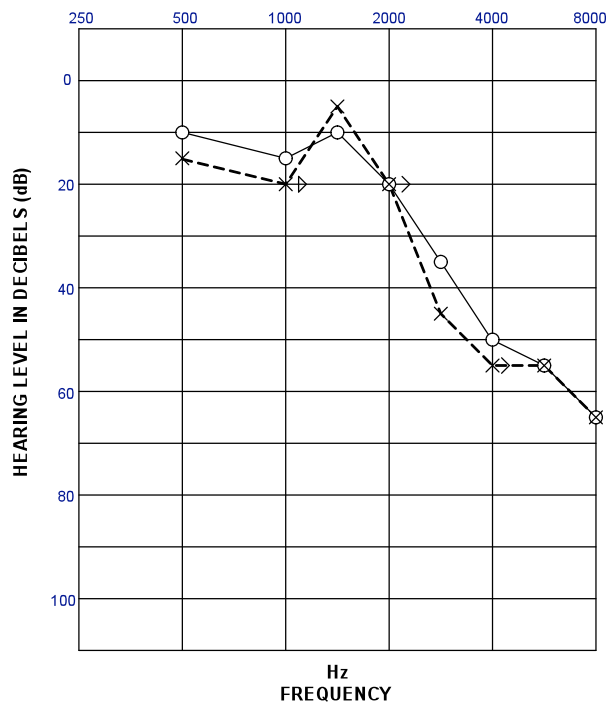
Served in the Dutch army, where he was exposed to rifle fire only during his basic training. Moved to New Zealand in 1950. Worked with the Ministry of Works in Otago, where he was involved with rock drilling and heavy earthmoving machinery, but did not operate machinery himself. Worked in a supervisory capacity as a surveyor. He later worked in a supervisory capacity with Downer & Co in a quarry situation as well as a pulp mill.

Examination

Normal tympanic membranes on microscopy.

Audiogram

- Bilateral symmetrical sensorineural high frequency loss.
- Audiogram not typical of NIHL.



	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	10	15	10	20	35	50	55	65	7.6
Left	15	20	5	20	45	55	55	65	10.7
Binaural									8.6

Conclusion

Total hearing loss	8.6%
Net loss age-adjusted	0%
Occupational NIHL apportionment	0%

Comments

- The patient's hearing loss is consistent with presbycusis. The degree of hearing loss is less than the standard age deduction for an 80-year-old man. Therefore no other cause is necessary to explain the degree of hearing loss.
- Being employed in a noisy industry does not of itself imply exposure to dangerous noise levels. Supervisors and other office workers do not necessarily encounter hazardous noise. Take care when interpreting job descriptions to ascertain details of noise exposure.

Example of multiple sources of noise exposure: Case 5

History

52-year-old male. Under treatment for non-insulin-dependent diabetes mellitus. No other risk factors.

Past history

Trauma to the ear and head, but no remembered association with hearing loss. Tinnitus for 15 years.

Non-work noise

Carpentry at home, including building two houses for himself in Australia; recreational shooting of deer and goats (2,000 rounds per year using a variety of weapons). Right-handed shooter.

Occupational history

Five years of carpentry; five years of very noisy demolition work, then 20 years of noisy concrete-placing work. Only about half the exposure was in New Zealand.

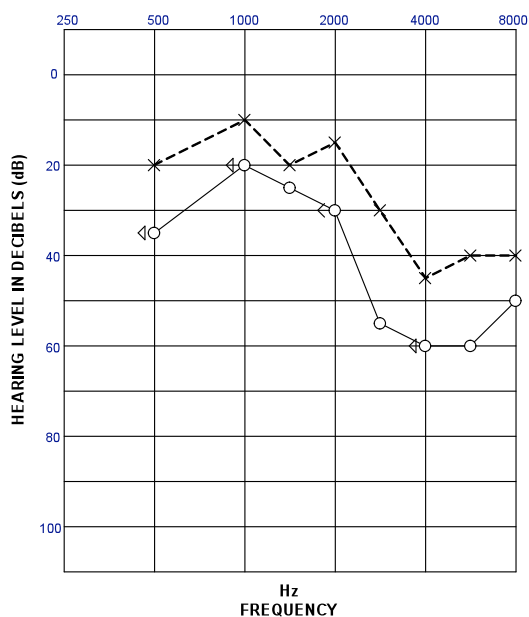
Examination

All normal.

Audiogram

The features are:

- bilateral sensorineural moderate notched hearing loss, worse on the right, with some low frequency involvement
- 10% total hearing loss (Right: 20.2%, Left: 5.6%)
- assessor's opinion: nominal 5.6% ONIHL binaural loss, based on the left-sided thresholds – right-sided additional loss probably attributable to recreational shooting
- no age adjustment necessary
- assessor reduced ONIHL apportionment to 3.5% because the client was exposed to loud occupational noise outside New Zealand for 17 years.



	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	35	20	25	30	55	60	60	50	20.2
Left	20	10	20	15	30	45	40	40	5.6
Binaural									10.0

Conclusion

Total hearing loss	10.0%
Other factors	4.4%
Total ONIHL apportionment	5.6%
Occupational NIHL in NZ	3.5%

Comments

- To calculate the impact of ONIHL, the assessor has assumed that the binaural hearing would be the same as the current hearing loss on the left. That is, the appropriate binaural percentage loss of hearing would be the same as the monaural PLH on the left – 5.6%.
- Because only about half the exposure was in New Zealand, the assessor has estimated the PLH caused by occupational noise exposure in New Zealand as 3.5%.
- The remaining 4.4% related to the additional hearing loss on the right remains unexplained. The asymmetry is incompatible with the effects of shooting (being on the wrong side for that explanation to be coherent).

Example of non-New Zealand noise exposure: Case 6

History

79-year-old male. Only aware of hearing loss for one year.

Past history

Nil military, head injury, family history, ototoxic drug exposure.

Non-work noise

Mower, power tools, with no ear protection. Occasionally used a .303 rifle in his youth.

Occupational history

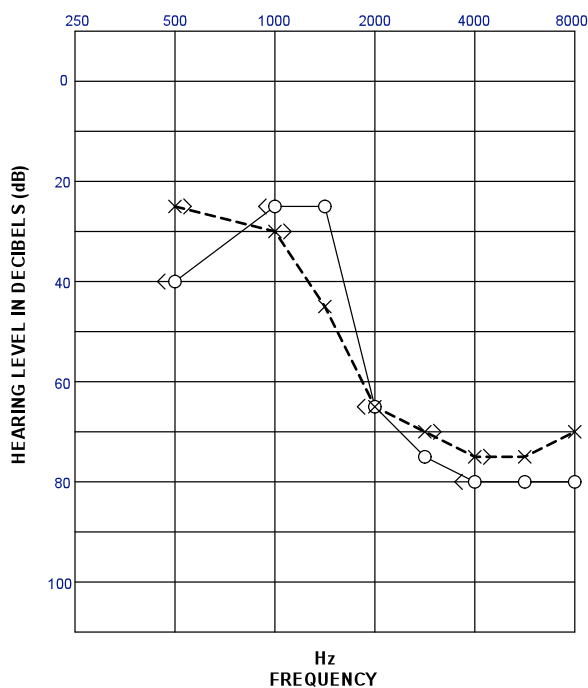
Boilermaker in Australia 1944-1968, and then in New Zealand until 1986. He believed that the environments in which he worked in New Zealand had higher noise levels than in Australia because they were primarily indoors.

Examination

Nil of note.

Audiogram

- First audiogram showed 50 dB HL at 500 Hz on the right, and 45 dB on the left. Speech discrimination indicated 90% discrimination at 60 dB HL on the right, and 93% at 80 dB HL on the left. Audiogram below is the result of repeated testing.
- High frequency loss was moderately severe, with mild to moderate hearing loss also present in low frequencies.
- The hearing loss in the lower frequencies is unlikely to be related to noise exposure.



	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	40	25	25	65	75	80	80	80	37.4
Left	25	30	45	65	70	75	75	70	39.3
Binaural									35.5

Conclusion

Total hearing loss	35.5%
Net loss age-adjusted	22.7%
Occupational NIHL apportionment – total	17.7%
Occupational NIHL apportionment – NZ	10.5%
Other cause	5.0%

Comments

- This is a difficult case to assess because of the unreliability of the thresholds, with the assumption being made that pure-tone thresholds have been deliberately elevated. The calculations are based on the PLH for the best thresholds obtained during repeated testing.
- In cases like this, where there is concern about the validity of the audiometry, further assessment may be helpful.
- The standard age deduction has been made.
- A further deduction for hearing loss in the low frequencies (i.e. below 2 kHz) has been made (an estimated 5%).
- The resulting 17.7% attributed to occupational noise exposure has been divided, with slightly more than half being attributed to damage in the New Zealand workplace – because of the reported higher noise levels from indoor reverberant environments.
- Assessors should not accept all such comments at face value – some reference to the literature or to peers experienced in occupational assessments would be advisable.

Example of multiple causes of hearing loss: Case 7

History

69-year-old male. Failed compulsory military uptake at 18 years because of hearing loss on the right. Non-insulin-dependent diabetic for the last 10

Past history

History of ear infections as a child, with long history of grade 1 bilateral fairly continual tinnitus. No history of head injury.

Non-work noise

Recreational shooting, mainly for deer. Used protectors on the range.

Occupational history

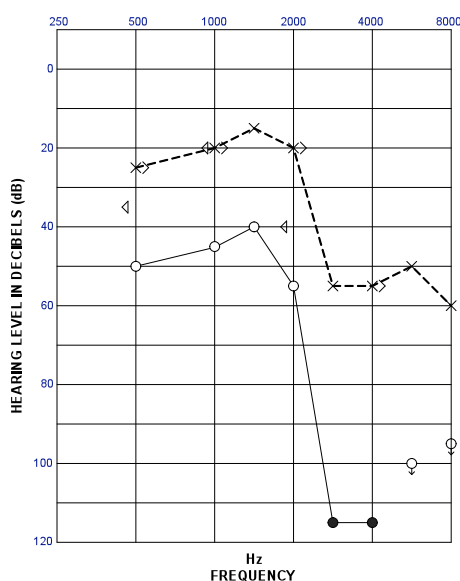
Panel beater from the age of 15 until he retired at 65. Wore ear protection only intermittently from the 1970s – began using it properly from the 1990s.

Examination

Right eardrum scarred with shortened retracted malleus and grade 2 retraction posteriorly onto the long process of the incus. He was able to valsalva and move this pocket off the incus. Left eardrum appeared normal. Rinne negative in the right, positive in the left. Weber test localised to his worse hearing right ear due to his conductive loss. His nose and throat looked normal.

Audiogram

- Similar results to a test elsewhere three months ago.
- Moderate to severe mixed loss on the right. Conductive component consistent with middle ear dysfunction.
- Moderate high frequency sensorineural loss on left.
- 100% speech discrimination both sides.



	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	50	45	40	55	115	115	100+	95+	54.7
Left	25	20	15	20	55	55	50	60	13.3
Binaural									22.6

Conclusion

Total hearing loss	22.6%
Adjustment for conductive component	9.8%
Net sensorineural loss	13.3%
Net loss age-adjusted	9.0%
Recreational shooting	1.0%
Occupational NIHL apportionment	8.0%

Comments

- In this case, there is a clear conductive element to the hearing loss on the right.
- It is a reasonable assumption that the sensorineural hearing loss component can be assessed from the hearing loss on the left (i.e. use the left monaural PLH to estimate the binaural sensorineural PLH).
- The standard age deduction of 4.3% leaves an NIHL of 9.0%.
- A small deduction (1%) has been made for recreational shooting, leaving 8.0% attributed to occupational noise. However, the report includes insufficient detail about the shooting history to support this apportionment.

Example of multiple causes of hearing loss: Case 8

History

62-year-old farmer who has noticed hearing difficulties for the last 30 years, with the left ear always worse than the right.

Past history

No other issues.

Non-work noise

Shooting, mainly for claybirds – 100-200 shots per year. Right-handed shooter.

Occupational history

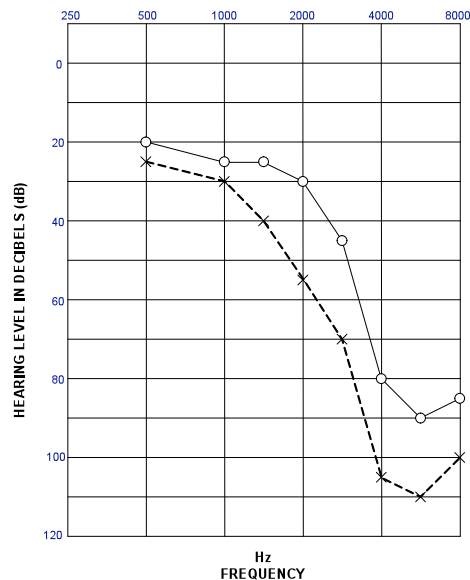
Sheep and beef farmer for 30 years. The main source of noise exposure was a two-stroke weed-sprayer used for about six weeks per year for about 40 hours per week. He noticed pain during use and muffled hearing with tinnitus afterwards. In addition, chainsaws were used for a few hours per week, motorbikes and quad bikes up to eight hours per day during lambing, otherwise two hours per day.

Examination

No abnormality other than hearing loss. Rinne positive bilaterally; Weber to right.

Audiogram

- Bilateral asymmetrical high frequency sensorineural loss, severe in the high frequencies.
- Degree of loss inconsistent with being caused solely by noise.
- Reasonable to assume that Mr S was exposed to very high intensity noise (possibly up to 100 dB) for a for a cumulative total of 5.5 years. Using ISO 1999, a median loss of 10% might be expected.



	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	20	25	25	30	45	80	90	85	19.1
Left	25	30	40	55	70	105	110	100	37.4
Binaural									24.0

Conclusion

Total hearing loss	24.0%
Net loss age-adjusted	22.5%
Occupational NIHL apportionment	10.0%
Other cause	12.5%

Comments

- This man has a much greater degree of hearing loss in the high frequencies than would be predicted from the degree of noise exposure.
- A small age deduction has been made.
- The assessor has then used epidemiological data from ISO 1999 to estimate the maximum amount of hearing loss that could be expected to result from the noise exposure reported.
- The cause of the rest of the hearing loss is unknown – so by default can be attributed to idiopathic cochlear loss.
- Note that no comment was made in the report about the use of hearing protectors – the assumption from the report is that there was none.
- The degree of asymmetry is considerable, and merits further investigation.

Example of progressive cochlear hearing loss: Case 9

History

59-year-old male aware of hearing loss for 10-20 years. He has not been exposed to noise over this time, but has noticed a deterioration over the period, and more significantly in the last six months.

Past history

Nil of note.

Non-work noise

None of significance.

Occupational history

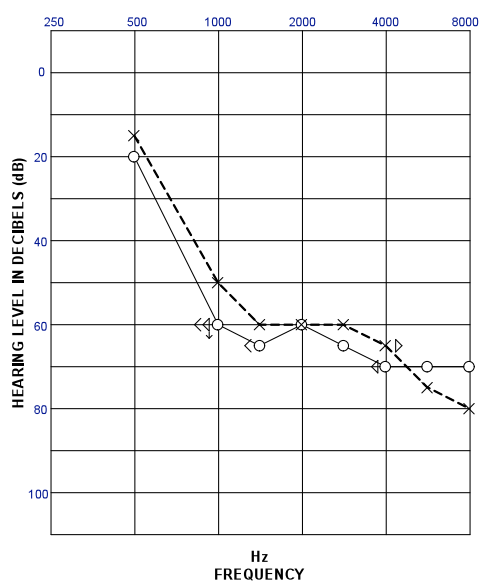
Employed for 9.5 years in woollen mills. From 1973 to 2005 he worked in quiet environments as a storeman, undertaking market research, and as a taxi-driver. Has been unemployed for the last two years.

Examination

Nil of note.

Audiogram

- Symmetrical hearing loss, normal at 500 Hz, moderately severe at frequencies of 1,000 Hz and above.
- Degree of hearing loss at 1 kHz and 2 kHz significantly greater than reported for weavers with 10 years' exposure.
- ONIHL apportionment comprised an estimate based on published data for hearing loss from 10 years' exposure for weavers (5.6%).
- Assessor referred for further audiological tests, which indicated cochlear hearing loss. Blood screening for auto-immune disorders was also ordered, but results were not available on the file.



	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	20	60	65	60	65	70	70	70	54.1
Left	15	50	60	60	60	65	75	80	47.8

Conclusion

Total hearing loss	48.7%
Net loss age-adjusted	48.0%
Occupational NIHL apportionment	5.6%
Other cause	42.4%

Comments

- The primary cause of hearing loss for this man was felt to be progressive cochlear degeneration.
- He had not been exposed to occupational noise for many years.
- However, because he had experienced 10 years of exposure to noise in his youth, an evidence-based apportionment for ONIHL was made.
- Note that the employment history was not sufficiently detailed – not everyone employed in noisy industries is exposed to hazardous levels of noise.
- The particular comparative figures chosen (jute weavers) relate to average exposures of 100 dB(A) – it may be that this is an over-estimate of noise in the particular woollen mill, but the attempt to seek appropriate evidence is laudable.

Example of progressive cochlear hearing loss: Case 10

History

58-year-old male with an eight-year history of noise exposure in the rendering department of a freezing works. Hearing loss developed at that time, and progressed to result in a significant hearing loss.

Past history

A claim had been accepted in 1992, and an apportionment had been made of 18.2% related to occupational noise-induced hearing loss.

Non-work noise

Nil reported.

Occupational history

Between 1986 and 1994 he worked in a freezing works, adjacent to hoggers – a very noisy type of machinery used in rendering departments, generating an average L_{eq} 95-100 dB(A). He had not used hearing protection.

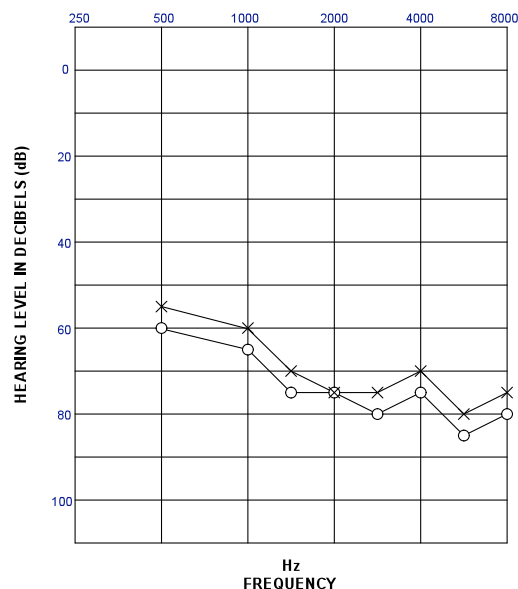
Examination

Nil of note.

Audiogram

The features are:

- fairly flat bilateral moderate-severe sensorineural hearing loss, 60-80 dB, age-adjusted to 71.9%
- symmetrical.



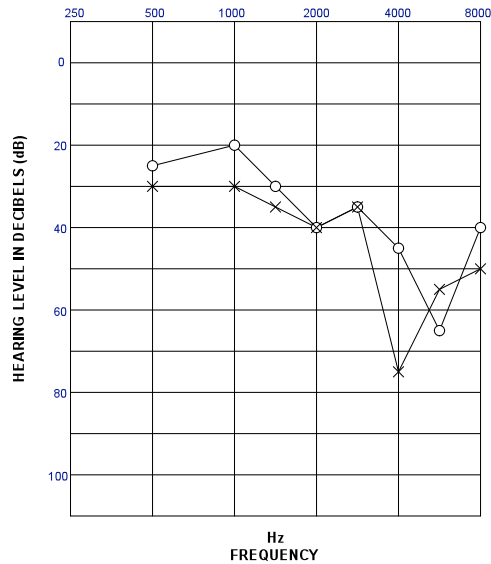
	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	60	65	75	75	80	75	85	80	77.4
Left	55	60	70	75	75	70	80	75	71.5
Binaural									72.4

Initial ORL assessment

Based on the exposure to damaging occupational noise and the presence of a significant loss, 16.6% ONIHL was assessed with the remainder being related to idiopathic cochlear degeneration.

ORL review

The reviewer sought further details of the occupational history. Eventually an audiogram from 1992 was located in the records of a private audiologist in the client’s home town (see below).



	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	25	20	30	40	35	45	70	40	16.6
Left	30	30	35	40	35	75	55	50	24.7
Binaural									18.6

This showed a fairly flat sensorineural hearing loss of 18.6% with notching at 4 or 6 kHz. Hearing loss in the frequencies 3-8 kHz totalled 6.7%, and it was considered that a fair proportion of this loss was likely to be caused by his idiopathic cochlear degeneration rather than occupational noise. An apportionment of 3-4% was recommended.

Comments

- Older ONIHL assessments need to be treated with reservations. They are often over-generous by today’s standards.
- Historical audiometry is supremely important. Although it can take some time, diligently searching for old audiometric records can be very helpful.
- It is a mistake to apportion all hearing loss in the high frequencies to ONIHL when there is marked additional pathology. The additional pathology will almost certainly affect the high frequencies to some extent.

Example of progressive cochlear hearing loss: Case 11

History

70-year-old female who complained of progressive hearing loss over 15 years, now significantly impacting her life. No other symptoms.

Past history

None.

Non-work noise

Nil.

Occupational history

Between 1963 and 1985 she worked as a machinist for a clothing manufacturer in a workshop with a number of other individuals using commercial sewing machines. It was a very noisy environment and it was necessary to shout to communicate with other workers.

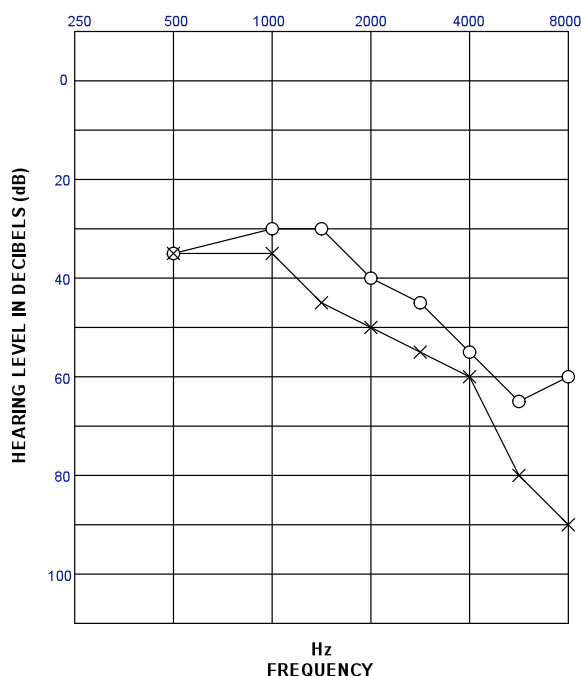
Examination

Whispered voice moderately reduced each ear, tympanic membranes normal, Rinne positive each ear, Weber central.

Audiogram

The features are:

- bilateral sensorineural hearing loss, moderate across frequencies, worse in the upper frequencies; 28.5 binaural loss, age-adjusted to 28.1%
- slight asymmetry – left more than right
- slight notch at 6 kHz in right ear.



	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	35	30	30	40	45	55	65	60	25.4
Left	35	35	45	50	55	60	80	90	38.5
Binaural									28.5

Initial ORL assessment

Based on the likelihood of exposure to damaging occupational noise and the presence of a high frequency notched loss, 9.2% ONIHL was assessed – this being the hearing loss in the frequencies 3-8 kHz.

ORL review

The reviewer sought further details of the occupational history. The client worked for 22 years in a workshop with 30 other individuals using industrial sewing machines driven by electric motors that produced a loud humming noise, or, occasionally in older machines, a clattering noise. The work almost entirely involved using straight sewing machines and overlocking machines. Noise exposure was for approximately six hours per day. She would have to raise her voice to speak to the neighbouring machinist working 1.5-2 metres away.

The reviewer obtained Department of Health data dated 1986 for the clothing manufacturing industry. These data indicated that straight sewing machines were measured at L_{eq} 79 dB(A) and overlockers at L_{eq} 78 dB(A). Given that there were about 30 machines operating, the overall noise levels would have been equivalent to 85-90 dB(A), consistent with the client's comments about communication difficulties in her place of work.

On the basis that occupational noise exposure was for six hours per day, an assumption of 85 dB exposure for 20 years led to an estimate of a maximum (90th percentile) estimate of 8.0% ONIHL – somewhat below the original assessment.

Comments

This case represents a very common scenario, in which a client's hearing loss is clearly likely to be partly or substantially due to non-occupational pathology – most commonly enhanced presbycusis or idiopathic cochlear degeneration – but there is a noise exposure history in the past suggesting that some of the hearing loss in the high frequencies might be occupational. Noise exposure ceased at the age of 46 years, and the symptoms of hearing loss were first noted at the age of 55, progressing after this.

The initial assessor contended that a significant but sub-clinical hearing loss existed at the time she finished work, but only manifested itself with the subsequent addition of presbycusis. Based on the client's account of communication difficulties in her workplace and noise data from the era, the reviewer came to a similar conclusion.

A number of important principles are illustrated by this case.

- The occupational noise history is of paramount importance.
This must be established by a painstaking history from the client, backed up, wherever possible, by data from the employer or from industry-related noise surveys. At times advice may need to be sought from an occupational physician knowledgeable about noise levels in various industries.
- Historical audiometry can be very important.
In this case, a post-employment audiogram (if available) would have probably resolved the issue. Such evidence should be enquired about and searched for.
- Doubtful cases can be resolved on the balance of probabilities.
In cases where attribution of cause is ambiguous, we are helped by the legal requirement in civil proceedings – namely, to give an opinion on the balance of probabilities – or whether it is more probable than not that something has occurred. In this case, reference to ISO 1999 data indicated that the original apportionment was almost certainly an over-estimate.

Appendix A: ACC723 Hearing Loss Assessment Specialist Otolaryngologist Report



HEARING LOSS ASSESSMENT Specialist Otolaryngologist Report



Complete this form to report your assessment for occupational noise-induced hearing loss.
Please send the completed form to your regional service centre:

Hamilton.HearingLoss@acc.co.nz
ACC Hamilton Service Centre, PO Box 952, Hamilton 3240

Dunedin.HearingLoss@acc.co.nz
ACC Dunedin Service Centre, PO Box 408, Dunedin 9054

PART ONE: BACKGROUND

1. ACC

ACC Client Service staff member:	ACC Office:
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2. PROVIDER

Provider name:	Provider number:
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3. CLIENT

Client name:	
Claim number:	Date of birth:

4. ASSESSMENT

Date of assessment:	Purchase order number:
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PART TWO: REPORT

1. PREVIOUS TREATMENT AND REHABILITATION

Please record details of the client's previous hearing loss claim/s, assessment/s and/or treatment (*please provide copies of any newly obtained results*)

2. CLIENT HISTORY

Have you reviewed all of the information on the *Hearing Loss Client Questionnaire (ACC724 or ACC613)*? Yes No

Please outline your clinical history of the hearing loss obtained directly from the client:

Occupational noise exposure

Based on the Hearing Loss Client Questionnaire and other sources of information, does the client have a history consistent with exposure to hazardous levels of noise within New Zealand? Yes No

If so, please detail the overall duration, nature and equivalent intensity level of the client's noise exposure, making allowance for the use of hearing protection and its probable effectiveness:

Military noise exposure

Does the client have a history consistent with exposure to noise in the military likely to cause hearing loss? Yes No

If so, please provide details:

Non-work-related noise exposure	
Does the client have any exposure to non-work-related noise likely to cause hearing loss?	<input type="checkbox"/> Yes <input type="checkbox"/> No
If so, please provide details:	
Head injury or traumatic ear injury	
Does the client have a history of head injury or trauma to the ear/s that is a contributing factor in their current levels of hearing loss?	<input type="checkbox"/> Yes <input type="checkbox"/> No
If so, please provide details (including whether an ACC claim was lodged):	
Family history	
Does the client have a family history of hearing loss?	<input type="checkbox"/> Yes <input type="checkbox"/> No
If so, please provide details:	
Ototoxicity	
Does the client have a history consistent with exposure to drugs that might have caused or contributed to hearing loss?	<input type="checkbox"/> Yes <input type="checkbox"/> No
If so, please provide details, including dates of use and the purpose for which the drugs were prescribed:	
Does the client have a history consistent with exposure to other ototoxic agents that might have caused or contributed to hearing loss?	<input type="checkbox"/> Yes <input type="checkbox"/> No
If so, please provide details:	

3. CLINICAL EXAMINATION

Please document your clinical findings (eg right ear, left ear, nasal function, hearing, and balance if appropriate):	
Have you identified any factors other than noise exposure that might cause or contribute to hearing loss?	<input type="checkbox"/> Yes <input type="checkbox"/> No
If so, please describe:	

4. HEARING LOSS AUDIOMETRIC REPORT (ACC612)

If more than one ACC612 is available, please state the date on which this report is based:	
Where earlier audiograms are available, please comment on their significance:	
Are you satisfied that the audiometric evaluation is complete and sufficient for your diagnostic purposes?	<input type="checkbox"/> Yes <input type="checkbox"/> No
If not, please explain why:	
Please specify other tests that you believe are required, and the reasons:	

5. SUMMARY AND RECOMMENDATIONS

Summary of hearing loss	
On the basis of the audiometric findings, please describe the client's hearing loss:	
Apportionment of causes (<i>refer to Assessment of Occupational Noise-Induced Hearing Loss for ACC</i>)	
What is the client's...	
Total percentage of binaural loss:	
Percentage of binaural loss correction for presbycusis:	

Net age-corrected hearing loss:
Percentage of binaural loss attributed to other factors:
Percentage of binaural loss attributed to occupational noise-induced hearing loss (NIHL):
Opinion
<p>Is the client's pattern of hearing loss typical of the effects of noise? <input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>If not, and you believe it to be work-related NIHL please explain why:</p> <p>Summarise your view of the case, explaining your apportionment of the client's hearing loss between occupational NIHL and other causes:</p> <p>In your opinion, what employer/s or job task/s are most likely to have caused or contributed to the client's hearing loss within the NZ workplace?</p> <p>Do you think any other information or expert opinion would be beneficial in further assessment of this case? <input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>If so, please provide details:</p>
Hearing rehabilitation
<p>Is a trial of hearing aids recommended for this client's hearing loss? <input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>If so, is the need for aids <input type="checkbox"/> Binaural <input type="checkbox"/> Right only <input type="checkbox"/> Left only <input type="checkbox"/> Other</p> <p>Please comment on the client's wish for and/or motivation to use rehabilitative devices:</p>

PART THREE: DECLARATION AND SIGNATURE

SPECIALIST SIGNATURE	
I declare the following conflicts of interest together with any mitigating action I have taken in carrying out this assessment:	
Signature: _____	Date: _____
Name: _____	

The information collected on this form will only be used to fulfil the requirements of the Accident Compensation Act 2001. In the collection, use and storage of information, ACC will at all times comply with the obligations of the Privacy Act 1993 and the Health Information Privacy Code 1994.

If a new ACC612 report has been completed, please attach.



Hearing Loss – Client Questionnaire



1. CLIENT

Name:	ACC claim number:		
Phone number:	Date of birth:		
Place of birth:	Date of residency (if not born in NZ):		
Current employment status:	<input type="checkbox"/> Employee	<input type="checkbox"/> Self-employed	<input type="checkbox"/> Retired or not working
Employer/company (if employed):			
ACC number or IRD number (if self-employed):			
Date you stopped working (if retired or not working):			

2. BACKGROUND

Previous hearing tests	
Have you had hearing tests either at work or in a clinic before making this claim?	<input type="checkbox"/> Yes <input type="checkbox"/> No
If yes when and where was this? _____	
<i>Please attach hearing test results (if available) to this completed questionnaire before sending it to ACC</i>	
Previous ENT (Ear Nose and Throat) specialist information	
Have you seen an ENT specialist in the past for your ears, or do you have an appointment to see an ENT specialist?	<input type="checkbox"/> Yes <input type="checkbox"/> No
If 'yes', please: provide details _____ _____ _____	
First awareness of hearing difficulties	
When did you first notice problems with your hearing? _____ _____	
Medical problems	
Have you ever had a serious head injury that might have affected your hearing?	<input type="checkbox"/> Yes <input type="checkbox"/> No
Have you had any serious illness (eg cancer requiring chemotherapy, TB, meningitis, kidney failure) or treatment which you think might have affected your hearing?	<input type="checkbox"/> Yes <input type="checkbox"/> No
If yes, please describe: _____ _____	
Family history	
Have any blood relatives (whether still alive or not) had a hearing loss problem?	<input type="checkbox"/> Yes <input type="checkbox"/> No
If yes, please give details: _____ _____	

3. WORK

Please complete the table below, to the best of your knowledge, describing all periods of employment and self-employment since leaving school. Include employment in New Zealand as well as overseas (stating whether you paid New Zealand income tax on your overseas earnings).

Employer's name and nature of business	Years employed (eg 1984 – 1996)	Was this in New Zealand?	List your work duties and sources of noise in that job (specify the tools or machinery)	Noise types (select option that best describes noise levels)	Hours of loud noise exposure	Did you have to shout to be heard when the noise was loud?	Did you wear hearing protection? If so, what sort?
	_____ to _____	<input type="checkbox"/> Yes <input type="checkbox"/> No If 'No' did you pay NZ income tax on overseas earnings? <input type="checkbox"/> Yes <input type="checkbox"/> No		<input type="checkbox"/> Explosion <input type="checkbox"/> Rifle fire <input type="checkbox"/> Jet aircraft taking off <input type="checkbox"/> Chainsaw operating <input type="checkbox"/> Grinding metal, noisy lawnmower <input type="checkbox"/> Heavy truck operating <input type="checkbox"/> Noise in busy street <input type="checkbox"/> Assembly work with noisy tools <input type="checkbox"/> Busy office	<input type="checkbox"/> 1-2 hours/day <input type="checkbox"/> 2-4 hours/day <input type="checkbox"/> 4-6 hours/day <input type="checkbox"/> 6-8 hours/day <input type="checkbox"/> 8 hours/day _____ days/week	<input type="checkbox"/> Yes <input type="checkbox"/> Sometimes <input type="checkbox"/> No	<input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Never ***** <input type="checkbox"/> Earmuffs <input type="checkbox"/> Earplugs
	_____ to _____	<input type="checkbox"/> Yes <input type="checkbox"/> No If 'No' did you pay NZ income tax on overseas earnings? <input type="checkbox"/> Yes <input type="checkbox"/> No		<input type="checkbox"/> Explosion <input type="checkbox"/> Rifle fire <input type="checkbox"/> Jet aircraft taking off <input type="checkbox"/> Chainsaw operating <input type="checkbox"/> Grinding metal, noisy lawnmower <input type="checkbox"/> Heavy truck operating <input type="checkbox"/> Noise in busy street <input type="checkbox"/> Assembly work with noisy tools <input type="checkbox"/> Busy office	<input type="checkbox"/> 1-2 hours/day <input type="checkbox"/> 2-4 hours/day <input type="checkbox"/> 4-6 hours/day <input type="checkbox"/> 6-8 hours/day <input type="checkbox"/> 8 hours/day _____ days/week	<input type="checkbox"/> Yes <input type="checkbox"/> Sometimes <input type="checkbox"/> No	<input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Never ***** <input type="checkbox"/> Earmuffs <input type="checkbox"/> Earplugs
	_____ to _____	<input type="checkbox"/> Yes <input type="checkbox"/> No If 'No' did you pay NZ income tax on overseas earnings? <input type="checkbox"/> Yes <input type="checkbox"/> No		<input type="checkbox"/> Explosion <input type="checkbox"/> Rifle fire <input type="checkbox"/> Jet aircraft taking off <input type="checkbox"/> Chainsaw operating <input type="checkbox"/> Grinding metal, noisy lawnmower <input type="checkbox"/> Heavy truck operating <input type="checkbox"/> Noise in busy street <input type="checkbox"/> Assembly work with noisy tools <input type="checkbox"/> Busy office	<input type="checkbox"/> 1-2 hours/day <input type="checkbox"/> 2-4 hours/day <input type="checkbox"/> 4-6 hours/day <input type="checkbox"/> 6-8 hours/day <input type="checkbox"/> 8 hours/day _____ days/week	<input type="checkbox"/> Yes <input type="checkbox"/> Sometimes <input type="checkbox"/> No	<input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Never ***** <input type="checkbox"/> Earmuffs <input type="checkbox"/> Earplugs

Employer's name and nature of business	Years employed (eg 1984 – 1996)	Was this in New Zealand?	List your work duties and sources of noise in that job (specify the tools or machinery)	Noise types (select option that best describes noise levels)	Hours of loud noise exposure	Did you have to shout to be heard when the noise was loud?	Did you wear hearing protection? If so, what sort?
	_____ to _____	<input type="checkbox"/> Yes <input type="checkbox"/> No If 'No' did you pay NZ income tax on overseas earnings? <input type="checkbox"/> Yes <input type="checkbox"/> No		<input type="checkbox"/> Explosion <input type="checkbox"/> Rifle fire <input type="checkbox"/> Jet aircraft taking off <input type="checkbox"/> Chainsaw operating <input type="checkbox"/> Grinding metal, noisy lawnmower <input type="checkbox"/> Heavy truck operating <input type="checkbox"/> Noise in busy street <input type="checkbox"/> Assembly work with noisy tools <input type="checkbox"/> Busy office	<input type="checkbox"/> 1-2 hours/day <input type="checkbox"/> 2-4 hours/day <input type="checkbox"/> 4-6 hours/day <input type="checkbox"/> 6-8 hours/day <input type="checkbox"/> 8+ hours/day _____ days/week	<input type="checkbox"/> Yes <input type="checkbox"/> Sometimes <input type="checkbox"/> No	<input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Never ***** <input type="checkbox"/> Earmuffs <input type="checkbox"/> Earplugs
	_____ to _____	<input type="checkbox"/> Yes <input type="checkbox"/> No If 'No' did you pay NZ income tax on overseas earnings? <input type="checkbox"/> Yes <input type="checkbox"/> No		<input type="checkbox"/> Explosion <input type="checkbox"/> Rifle fire <input type="checkbox"/> Jet aircraft taking off <input type="checkbox"/> Chainsaw operating <input type="checkbox"/> Grinding metal, noisy lawnmower <input type="checkbox"/> Heavy truck operating <input type="checkbox"/> Noise in busy street <input type="checkbox"/> Assembly work with noisy tools <input type="checkbox"/> Busy office	<input type="checkbox"/> 1-2 hours/day <input type="checkbox"/> 2-4 hours/day <input type="checkbox"/> 4-6 hours/day <input type="checkbox"/> 6-8 hours/day <input type="checkbox"/> 8+ hours/day _____ days/week	<input type="checkbox"/> Yes <input type="checkbox"/> Sometimes <input type="checkbox"/> No	<input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Never ***** <input type="checkbox"/> Earmuffs <input type="checkbox"/> Earplugs
	_____ to _____	<input type="checkbox"/> Yes <input type="checkbox"/> No If 'No' did you pay NZ income tax on overseas earnings? <input type="checkbox"/> Yes <input type="checkbox"/> No		<input type="checkbox"/> Explosion <input type="checkbox"/> Rifle fire <input type="checkbox"/> Jet aircraft taking off <input type="checkbox"/> Chainsaw operating <input type="checkbox"/> Grinding metal, noisy lawnmower <input type="checkbox"/> Heavy truck operating <input type="checkbox"/> Noise in busy street <input type="checkbox"/> Assembly work with noisy tools <input type="checkbox"/> Busy office	<input type="checkbox"/> 1-2 hours/day <input type="checkbox"/> 2-4 hours/day <input type="checkbox"/> 4-6 hours/day <input type="checkbox"/> 6-8 hours/day <input type="checkbox"/> 8+ hours/day _____ days/week	<input type="checkbox"/> Yes <input type="checkbox"/> Sometimes <input type="checkbox"/> No	<input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Never ***** <input type="checkbox"/> Earmuffs <input type="checkbox"/> Earplugs

4. OTHER NOISE EXPOSURE

Please complete the table below, describing your exposure to loud noises from sources such as car or personal stereos, hobby work using noisy equipment, recreational use of motor boats, playing a musical instrument, attending nightclubs / discos.

Activity / noise source (please answer all)	Years exposed (eg 1984 –1996)	Frequency of exposure (hours / week)	Did you wear hearing protection?
Lawnmowing <input type="checkbox"/> Yes <input type="checkbox"/> No	_____ to _____		<input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Never
Motor racing or moto-cross <input type="checkbox"/> Yes <input type="checkbox"/> No	_____ to _____		<input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Never
Operating chainsaw <input type="checkbox"/> Yes <input type="checkbox"/> No	_____ to _____		<input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Never
Using power tools <input type="checkbox"/> Yes <input type="checkbox"/> No	_____ to _____		<input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Never
Playing in a band <input type="checkbox"/> Yes <input type="checkbox"/> No	_____ to _____		<input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Never
Other - specify	_____ to _____		<input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Never
Other - specify	_____ to _____		<input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Never

Have you ever been caught unaware in an explosion? Yes No

If yes, please describe:

Have you ever been exposed to noise from guns or other firearms? Yes No

If yes, which shoulder do you shoot from?

Right

Left

If yes, please complete table below:

Type & calibre of firearm	Circumstances of firearms use (eg hunting, Territorials)	Years exposed (eg 1984 –1996)	Rounds fired / year	Did you wear hearing protection?
		_____ to _____		<input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Never
		_____ to _____		<input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Never
		_____ to _____		<input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Never

5. MILITARY

Have you ever been involved in military service?

Yes – please answer the following questions

No – go to next section

What is your service number: _____

Do you receive a War Pension for hearing loss?

Yes

No

Name of service & country served in	Nature of duties & sources of loud noise	Years exposed (eg 1984–1996)	Daily noise exposure (hours/day)	Did you wear hearing protection?
		_____ to _____		<input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Never
		_____ to _____		<input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Never
		_____ to _____		<input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Never
		_____ to _____		<input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Never

Is there any further information you would like to provide:

6.

I declare, that to the best of my knowledge, all the information I've provided on this form is true and correct.

Signature:

Date:

If the person completing this report is not the client

What is your name?

What is your relationship to the client?

Why is the client unable to complete the questionnaire?

The information collected on this form will only be used to fulfil the requirements of the Accident Compensation Act 2001. In the collection, use and storage of information, ACC will at all times comply with the obligations of the Privacy Act 1993 and the Health Information Privacy Code 1994.

Attached:

Copy of previous hearing tests

Yes No

To ensure prompt processing of your claim, please return this information within the next 14 days using the reply paid envelope.

Authorising a representative to act on your behalf

If your hearing problem means you have trouble using the phone, you can arrange for someone else to deal with ACC on your behalf.

This person can be a relative, friend or anyone who you trust to act as your representative.

However, because the information we hold about you is protected under the Privacy Act, you will need to complete the authorisation below to enable us to share this information with your representative.

CLIENT

Name:

ACC claim number:

REPRESENTATIVE

Name:

Relationship to you (eg spouse, partner, friend etc):

Phone number (if different from your number):

CLIENT

I authorise the above person to talk with ACC about my hearing loss claim. I understand that this authorisation applies only to my hearing loss claim, and I can cancel the authorisation at any time by advising ACC in writing.

Client signature:

Date:

The information collected on this form will only be used to fulfil the requirements of the Accident Compensation Act 2001. In the collection, use and storage of information, ACC will at all times comply with the obligations of the Privacy Act 1993 and the Health Information Privacy Code 1994.

Appendix C: Hearing handicap

Disability is the umbrella term in the WHO International Classification of Function framework for impairment, activity limitations and participation restrictions. The corollaries of these terms are the positively worded WHO terminology: function, activities and participation.

Table 1: Definitions and measures of impairment, disability and handicap, after Stephens and Hetu³⁴

Level	Definition	Measure	
Impairment			
Body	Loss or abnormality of psychological, physiological or anatomical structure or function	Simple <ul style="list-style-type: none"> • Sensitivity • Frequency resolution/discrimination • Temporal resolution • Tinnitus • Spatial resolution • Speech component processing • Intensity processing 	Complex <ul style="list-style-type: none"> • Speech discrimination in quiet • Speech discrimination in noise • Music recognition • Discrimination of environmental sounds
Disability (activity limitation)			
Person	Restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being	<ul style="list-style-type: none"> • Understanding speech • Listening to speech • Location in time and space • Identification • Tolerance of noise 	<ol style="list-style-type: none"> 1. Speech in quiet or noise <ul style="list-style-type: none"> • Live voice <ul style="list-style-type: none"> One-to-one Groups/meetings Theatre/opera In the car Strangers/dialects Religious services • Recorded voice <ul style="list-style-type: none"> Telephone TV/video Radio P/A systems Cinema 2. Signal detection <ul style="list-style-type: none"> Telephone bell Door bell Music Birdsong Water boiling 3. Localisation <ul style="list-style-type: none"> Warning signals Footsteps Traffic 4. Identification <ul style="list-style-type: none"> Music Birdsong Stethoscope Crossing signals 5. Environmental awareness <ul style="list-style-type: none"> Clock/watch Wind Traffic 6. Noise intolerance

³⁴ Stephens D, Hetu R. Impairment, disability and handicap in audiology: towards a consensus. *Audiology* 1991;30:185-200

Handicap (participation restriction)			
Person in society	A function of the relationships between disabled persons and their environment. It occurs when they encounter cultural, physical or social barriers that prevent their access to the various systems of society that are available to other citizens. Thus, handicap is the loss or limitation of opportunities to take part in the life of the community on an equal level with others.	<ol style="list-style-type: none"> 1. Orientation 2. Physical independence 3. Occupation 4. Economic self-sufficiency 5. Social integration 	<ol style="list-style-type: none"> 1) May require aids for listening; ease of listening dependent on levels of background noise; assistance may be required from others 2) Customary environment may create physical obstacles to independence; difficulty engaging in activities outside the home; may require assistance from others 3) May not be able to continue customary occupation without alterations of activities 4) Economic demands of disability may create economic hardship, depending on economic resources 5) Diminished participation, reduction in secondary contacts 6) Impact on significant others

A common use of disability measures is for evaluating the effectiveness of hearing aids – before and after fitting. They typically function both as measures of disability and as outcome measures.

Commonly used measures of disability include:

- HHI (Hearing Handicap Inventory)
- Hearing Aid Performance Inventory
- Abbreviated Profile of Hearing Aid Benefit (APHAB)
- Glasgow Hearing Aid Benefit Profile
- Self Assessment of Communication (SAC)
- Significant Other Assessment of Communication (SOAC).

A commonly used outcome measure that is not a standard disability measure is the Client Oriented Scale of Improvement (COSI), in which the client and clinician together develop goals for improvements in hearing function, against which the hearing aid performance is later assessed in both relative and absolute terms.

Hearing handicap can be measured by questionnaires such as the:

- Hearing Handicap Scale
- Hearing Measurement Scale
- Social Hearing Handicap Index
- Hearing Performance Inventory
- Quantified Denver Scale.

Appendix D: Medical Council of New Zealand: Non-treating doctors performing medical assessments of patients for third parties



MEDICAL COUNCIL OF NEW ZEALAND

DECEMBER 10

www.mcnz.org.nz

Non-treating doctors performing medical assessments of patients for third parties

Doctors who are employed by a third party to perform medical assessments of patients are required to maintain a professional standard of care within the framework of the assessing relationship and are expected to meet the standards of practice outlined in this statement.

Introduction

1. Medical assessments for third parties fall within the definition of the practice of medicine¹ and are a common feature of medical practice. The purpose of a medical assessment varies depending upon the role of the third party. Examples include assessment for employment suitability, and eligibility for health services or compensation. You may perform medical assessments as the patient's own doctor (also referred to as the treating doctor) or as a non-treating doctor.
2. In some circumstances you may be asked as the patient's own doctor to provide a medical assessment of the patient for a third party. Insurance companies and employers tend to use this form of assessment. You may also be employed or contracted as a non-treating doctor when a third party requires an independent assessment or second opinion. Examples include expert advisors (used in legal proceedings), doctors employed by organisations like ACC, insurance companies or the patient's employers.
3. As a non-treating doctor your assessment may take several forms, including a consultation with the patient, physical examination or a file review of the patient's medical history.

The role of the non-treating doctor

4. As a non-treating doctor your role is to perform a medical assessment and provide an impartial medical opinion to the third party who has employed or contracted you. As the title indicates, your role does not include providing any form of treatment to the patient.
5. Decisions made by a third party will be influenced by your opinion and this may affect the outcome for the patient. Therefore the Council considers that in making a recommendation you have a responsibility to ensure that your professional opinion and recommendations are accurate, objective and based on all the available evidence.

Performing medical assessments

6. If you do not consider yourself suitably qualified to conduct an assessment, or identify a conflict of interest, you must decline the referral. You do not have to provide the third party with an explanation.
7. If the third party considers that a physical examination is not required, you must be satisfied (and be able to justify) that you have all the information necessary to make an accurate assessment without performing a physical examination or speaking with the patient.

¹ As defined by the Council pursuant to sections 11 and 12 of the Health Practitioners Competence Assurance Act 2003. A copy of the definition of the practice of medicine can be found at www.mcnz.org.nz under Resources >> Medical Registration >> Definition of the practice of medicine.

The non-treating doctor and patient relationship – the standard of care within the framework of the assessing relationship

8. The basis of the relationship between the patient and you as an assessing doctor is not the same as that within an established doctor-patient relationship (even when you are also the patient's usual doctor), however patients being assessed are often vulnerable and you are still required to maintain a professional standard of care. The Council requires that non-treating doctors adhere to the principles in the Code of Health and Disability Services Consumers' Rights.
9. As such, you should treat the patient with respect, and ensure that they are free from coercion, discrimination, harassment and exploitation. If there is a meeting with the patient, you are required to respect the patient's dignity and communicate with the patient in a manner that enables him or her to understand the information provided and your role.

Effective communication and consent

10. The Council has identified some recurring problems in medical assessments performed by non-treating doctors. The common issue is poor communication with the patient. This leads to unmet expectations, misunderstandings and confusion about the non-treating doctor's responsibility to the patient. Therefore, if you are required to consult the patient:
 - You must ensure he or she understands the purpose of the medical assessment and your role. Although the patient will usually be informed of this by the third party before seeing you, you should confirm this and, if necessary, provide further explanation. This explanation should include discussion about the differences between your role and the role of the patient's own doctor.

- You must explain what will happen during the assessment and also ensure that the patient is aware of what you are doing throughout the consultation. This includes explaining the scope of the consultation and any tests that the assessment may require.
- You must obtain the patient's informed consent. You should ensure the patient understands that any aspect of the medical assessment may be included in the report to the third party. You should not proceed with the assessment if the patient does not provide his or her consent. You should also advise the patient that he or she has the right to withdraw from the assessment at any time, and inform him or her of any relevant policy held by the third party in relation to withdrawal of consent and the process he or she should follow to organise another assessment with a different doctor. In either of these circumstances you should record in your report to the third party at what point the assessment was terminated and why.
- You must explain and ensure that the patient understands what will happen after the consultation. Specifically, you must ensure the patient understands that the report will be the property of the third party. Any questions or requests for information should be directed through the third party.

Recording a consultation

11. A patient may want to record the consultation by video or audio tape. You should consider such a request carefully and, if you do not consent, ask the third-party to arrange for another doctor to conduct the assessment².

Reports for the third party

12. Once the medical assessment has been completed it is standard practice for the doctor who performed the assessment to provide a written report to the third party with his or her medical opinion. The report must be accurate and objective. You should not speculate or base recommendations on insufficient or flawed evidence

² *Jackson v ACC* (Wellington District Court, Decision No. 168/2002 dated 25 June 2002).

A doctor has the "privilege" to decide in what lawful way a medical examination will be conducted and the patient also has the "privilege" to ask for a tape-recorded consultation. It is then a question of balancing the reasonableness of the exercise of the mutual privileges. In this particular case the doctor had not put forward any worthy arguments to refuse to tape the consultation and given the patient's perception of her dealings with ACC and specialists appointed by it, her request to tape the examination was a reasonable exercise of her privilege to do so.

and if you are not satisfied that a medical opinion can be accurate, based on all the information provided in the file, you must clearly state this in the report. You may choose to recommend further methods of investigation if appropriate (i.e. medical tests, x-rays etc).

13. If you have been provided with any documentation or information from the third party this should be listed as part of your report. This ensures that this information can be referred to again if there are any issues or questions in the future.
14. If the third party has requested that you make recommendations (such as suitability for an employment position) these recommendations must not compromise the patient's safety.
15. It is the role of the third party to make the decisions for which they sought your advice. This includes decisions about eligibility for compensation and other benefits, and compliance with legislation. You should therefore restrict your comments to an assessment of medical issues.
16. The results of any tests or investigations you have ordered should be copied to the patient's usual doctor.
17. If you become aware of another medical condition as a result of your assessment, you should inform the patient and refer him or her back to his or her usual doctor for further investigation. You should notify the patient's usual doctor in writing. You should not notify the third-party unless your finding is relevant to their enquiries.

Medical assessments by the patient's usual doctor

18. In some circumstances you may be asked as the patient's usual doctor to perform a medical assessment that would otherwise be performed by a non-treating doctor. This is usually because the patient lives in an isolated area where a non-treating doctor is unavailable or in instances where it would be inappropriate to refer to an unknown treating doctor (such as where the patient has experienced sexual abuse). In this situation you should clearly explain the difference in your role, so that the patient understands that the usual dynamics of the doctor-patient relationship are different.
19. You must ensure that any medical assessment of a current patient for a third party is accurate, objective and based on all the available evidence.

File assessments by non-treating doctors

20. You may be employed or contracted as a non-treating doctor to perform a medical assessment based solely on information in the patient's file. In such circumstances, and as with any other form of medical assessment, you must be satisfied that you have all the information necessary and a physical examination is not required before providing your professional opinion or recommendation.
21. You should remember that the documented findings of another health practitioner have been based on physical examinations and direct communication with the patient. If you conclude that the documented cause of a medical condition or diagnosis is incorrect, you need to be confident that your conclusion can be supported with relevant evidence and is based on all the necessary information. It is not acceptable to include such conclusions in the report to the third party unless you are confident and can justify that consulting with the patient or the health practitioner who made the initial diagnosis is not necessary.

Financial influences for the non-treating doctors

22. You must not allow the financial interests of either the patient or the third party to influence your assessment, opinion or recommendations.

Review of medical assessment opinions

23. The Health and Disability Commissioner has concluded that complaints about the contents of an assessment report and complaints about purely paper-based reviews are usually not within the Commissioner's jurisdiction. The Commissioner cannot look into complaints about these matters, and you should direct such complaints directly to the third party, as the party best placed to address these concerns.
24. Concerns about the conduct of a non-treating doctor during a face-to-face assessment may fall within the Health and Disability Commissioner's jurisdiction, and such concerns should be directed to the Commissioner's office. However, concerns about a non-treating doctor providing an opinion on a matter outside his or her scope of practice, or a non-treating doctor's competence should be directed to the third party or the Medical Council.

Other relevant resources:

- The Medical Council of New Zealand has released a statement on *Medical certification* that outlines the general requirements and duties of a doctor when signing any form of certificate or medical report. This is available from the Council's website (www.mcnz.org.nz).
- There are several publications available from occupational groups that may assist doctors to understand the role of the independent or third party assessment. Both the Australasian and the United Kingdom Faculties of Occupational Medicine have released guidelines on this issue – guidelines are available on www.racp.edu.au/afom/ or www.facocmed.ac.uk.
- The NZMA Code of Ethics
- The Code of Health and Disability Services Consumers' Code of Rights

December 2010

This statement is scheduled for review by December 2015. Legislative changes may make this statement obsolete before this review date.

Appendix E: Coles, Lutman and Buffin: Guidelines on the diagnosis of noise-induced hearing loss for medicolegal purposes

Clin. Otolaryngol. 2000, **25**, 264–273

Guidelines on the diagnosis of noise-induced hearing loss for medicolegal purposes

R.R.A. COLES,* M.E. LUTMAN† & J.T. BUFFIN‡

*The MRC Institute of Hearing Research, University Park, Nottingham, †The Institute of Sound and Vibration Research, University of Southampton and the ‡Department of Medical Audiology, Royal Hallamshire Hospital, Sheffield, UK

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COLES R.R.A., LUTMAN M.E. & BUFFIN J.T.

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Guidelines on the diagnosis of noise-induced hearing loss for medicolegal purposes

These guidelines aim to assist in the diagnosis of noise-induced hearing loss (NIHL) in medicolegal settings. The task is to distinguish between possibility and probability, the legal criterion being 'more probable than not'. It is argued that the amount of NIHL needed to qualify for that diagnosis is that which is reliably measurable and identifiable on the audiogram. The three main requirements for the diagnosis of NIHL are defined: R1, high-frequency hearing impairment; R2, potentially hazardous amount of noise exposure; R3, identifiable high-frequency audiometric notch or bulge. Four modifying factors also need consideration: MF1, the clinical picture; MF2, compatibility with age and noise exposure; MF3, Robinson's criteria for other causation; MF4, complications such as asymmetry, mixed disorder and conductive hearing impairment.

Keywords *noise-induced hearing loss diagnosis medicolegal*

A probable diagnosis of noise-induced hearing loss (NIHL) is easy where there is a history of unprotected noise exposure of high level and long duration, a typical audiometric notch maximal at 3, 4, or 6 kHz and no evident complicating factor or diagnostic competitor. In many other cases though, the diagnosis is much less certain. In medicolegal work, the diagnosis may also be subject to challenge in correspondence, by instructing solicitors and those for the other party or parties, and under cross-examination in court.

In such cases, NIHL is usually accompanied, and often obscured, by age-associated hearing loss (AAHL) and sometimes by other additional forms of hearing impairment. The diagnostic task then reduces to that of defining the likelihood of the presence of a component of NIHL in the overall hearing impairment.

In defining likelihood, we are helped by the legal requirement in civil proceedings—namely to give an opinion on 'balance of probabilities' or whether it is 'more probable than not'. In practice, keeping that legal criterion in mind can be an enormous help. The expert witness is required only to

differentiate between probability and possibility, with the onus of proof of probability on the claimant. Nevertheless, a semi-quantitative opinion on the degree of probability can assist the court, by indicating how close to or distant from the borderline it is considered to be.

Another major issue is how much noise damage has to be present before it counts. The following statements encompass the range of criteria that might be used for this:

1. The risk of noise-induced destruction of at least some cochlear hair cells.
2. The slightest degree of damage that is likely to cause some minimal but finite degree of loss of hearing ability either now, or later when augmented by ageing effects.
3. The likelihood of causation of some specified degree of reduced hearing ability, below which the effect is regarded as of no importance.
4. The presence of a degree of noise-induced hearing loss that is large enough to be measurable reliably and identifiable on the audiogram.

Our opinion and decision on this matter is as follows. Statement (1) defies demonstration in living human beings and is therefore only of theoretical interest. Statement (2) borders on the concept of 'de minimis non curat lex', roughly translated as 'the law does not concern itself with

Correspondence: Dr Ross Coles, 22 Humber Road, Beeston, Nottingham, NG9 2EF, UK.

trifles.' With respect to hearing, this is for the courts to define when and if they wish to do so. For us to attempt a definition would be to invite disagreement and criticism from within the professions of otology and audiology, as well as being an incursion into legal prerogative where it might be seen to be usurping the role of the judiciary. Statement (3) is arbitrary, and medical and scientific opinions already vary widely on this. Statement (4) is the only practicable criterion for the amount of noise damage necessary for the diagnosis of NIHL; that is, a reliably measurable and identifiable degree of damage. This statement is also compatible with the legal requirement where the test is whether or not, on the balance of probabilities, noise has made a material contribution to the claimant's overall hearing impairment. This criterion is therefore the one on which the following diagnostic guidelines are based.

Historical background to these guidelines

The authors are not aware of any previously published quantitative guidelines for the diagnosis of NIHL. Operational criteria for diagnosis of the condition were therefore not included in the material presented in our annual 1-day course on 'Medicolegal aspects of noise-induced hearing loss', until 1998. Our change in policy on this issue arose from requests by participants, in the evaluation questionnaires for the 1997 course, for more information on how to diagnose NIHL. In fact, one of us (R.R.A.C.) had already been using his own rough set of criteria for medicolegal work for about 2 years. These then became the basis for our development of the first draft of these guidelines, which were then presented to the 1998 course.

They were then piloted through about 200 medicolegal cases during 1998, amended in places as a result, and then presented as a second draft set of guidelines to the 1999 course. With some further modifications, mostly of an editorial nature, they have now been finalised.

The guidelines are considered by the authors to be well-founded, practicable and useful. It is hoped that they will assist otologists and audiologists in making diagnoses in those many borderline cases that are troublesome. They may also assist the courts in adjudicating on these issues.

Guidelines on the diagnosis of noise-induced hearing loss

In order to keep the text of these guidelines as concise as possible, notes of explanation or further guidance have been placed in Appendix A and a worked example, comparing audiometric measurements with the most likely pattern and extent of AAHL, is given in Appendix B.

1. AIM

1.1. The aim of these guidelines is to assist expert medical witnesses in considering evidence for the diagnosis of NIHL in a medicolegal setting. They do not relate to hearing loss due to acute acoustic trauma, nor to noises having unusual frequency spectra (see para. 2.2), nor do they quantify how much of any hearing impairment is due to noise.

2. SCOPE

2.1. For the most part, the guidelines refer to uncomplicated cases of NIHL; that is, cases of 'typical' NIHL together with presumed 'normal' AAHL.

2.2. In the present context, 'typical' NIHL refers to the form of hearing impairment that gradually accrues in a proportion of those who have repeated exposures to hazardous levels of one or more of the common types of broad-band sound. Sounds not fitting this description include those predominantly of tonal nature or of low-frequency or very high-frequency spectrum. Examples of such unusual spectra would be where the sound level is > 10 dB greater in the 0.25, 0.5 or 8 kHz octave band than in each of the 1, 2 and 4 kHz octave bands.

2.3. 'Normal' AAHL here implies consistency with the range of age-associated hearing data in ISO 7029 (1984)¹ for the appropriate age and sex, and also having the most common audiometric configuration of AAHL in which the hearing loss increases progressively with test frequency and with age, the progression having an accelerating character.

3. GENERAL REMARKS

3.1. Inevitably, guidelines are a matter of judgement. They should be interpreted as guides, not rigid rules. Nevertheless, these guidelines have been derived after careful consideration of the data available and keeping in mind the legal criterion that the diagnosis should be likely 'on balance of probabilities' or 'more likely than not'.

3.2. It is not possible from case law or from scientific research to specify the minimum degree of NIHL that may be considered significant in terms of compensatability (see Note 1 in Appendix A). Consequently, guidelines on the minimum amount of noise exposure that might be significant must depend on the smallest hearing loss that can be measured in an individual with a reasonable degree of reliability. At 4 kHz, this is considered to be about 10 dB.

3.3. The guidelines presented here comprise three Requirements R1, R2 (a) or (b), R3(a) or (b) and four Modifying Factors MF1, MF2, MF3, MF4.

3.4. For the diagnosis of NIHL, requirements R1, R2(a) and R3(a) should be met; or if appropriate R1, R2(b) and R3(b). The diagnosis may then be strengthened or weakened

according to how modifying factors MF1, MF2, MF3 and MF4 apply to the individual.

Diagnostic requirements

4. REQUIREMENT R1: 'HIGH-FREQUENCY IMPAIRMENT'

4.1 R1 comprises audiometric evidence of a high-frequency sensorineural hearing impairment. For the present purposes, 'high-frequency' is defined relative to the threshold levels at middle frequencies. It is when a single measurement of hearing threshold level (HTL) at 3, 4 or 6 kHz, after any due correction for earphone type (see Note 2), is at least 10 dB greater than the HTL at 1 kHz or 2 kHz. If an average of two or more measurements in that ear can be used, the 10 dB guideline figure may be slightly reduced (see Note 3).

5. REQUIREMENT R2(a): 'NOISE EXPOSURE'

5.1. If R2(a) is met, at least 50% of individuals exposed to this known or estimated amount of noise would be likely to suffer a measurable degree of hearing loss. This noise estimate includes allowance for proper use of hearing protection (see Note 4) or for any in-built protection from a conductive hearing loss believed to have been present in the relevant noise-exposure years (see Note 5).

5.2. From an assessment of the various sets of epidemiological data and predictive formulae available (see Note 6), the lower limit of noise exposure meeting this requirement is considered to be an equivalent daily 8-h continuous noise exposure ($L_{EP,d}$) of not less than 85 dB(A) (see Notes 7 and 8) for a sufficient number of years to lead to a cumulative exposure of at least 100 dB(A) NIL, the so-termed Noise Immission Level.²⁻⁴

5.3. The medical examiner may not be able to make an estimate of the total noise exposure, even in terms of whether it meets R2(a) or (b). If a diagnosis of NIHL would be made if these noise exposure requirements were met, then it is recommended that in absence of a noise exposure estimate a conditional diagnosis be made.

6. REQUIREMENT R2(b): 'NOISE EXPOSURE'

6.1. Substantial amounts of NIHL can be caused in a minority of persons exposed to < 100 dB(A) NIL; that is, in those who are more than averagely susceptible. To allow for such cases, a less stringent noise exposure requirement is applicable provided the audiometric evidence of noise damage is stronger. The lower level of total noise exposure for such cases is reduced to 90 dB(A) NIL (see Notes 7 and 8), although the lower limit on $L_{EP,d}$ remains at 85 dB(A). Where the estimated total exposure is in the range 90–99 dB(A) NIL, thereby meeting noise exposure guideline R2(b)

but not R2(a), the audiometric guideline R3(b) must be met instead of R3(a).

7. REQUIREMENT R3(a): 'AUDIOMETRIC CONFIGURATION'

7.1. Evidence of probable presence of NIHL is considered to be present if there is a downward notch in the audiogram in the 3–6 kHz range that is large enough to be identifiable with a reasonable degree of confidence; see para. 7.5. An example of such a notch is shown in Fig. 1.

7.2. Evidence for NIHL is also provided on the audiogram by a sufficiently large relative bulge downwards and to the left in the 3–6 kHz range; see para 7.6. In a considerable proportion of NIHL cases, especially after the age of about 50 years, the characteristic high-frequency notch is missing. This is usually due to the additional presence of high-frequency hearing impairment of other causation, either pre-existing or developing concurrently or subsequently, such as associated with ageing. Typically that has the effect of converting a noise-induced audiometric notch into a bulge, an example of which is shown in Fig. 2 and also in Fig. 3 later. In other cases it may reduce the notch to a size (e.g. 5 dB) that is not significant as a notch. Nevertheless, it will add to the size of a potential bulge and should be examined closely to see if it qualifies as a bulge (see para. 7.6 and Note 10).

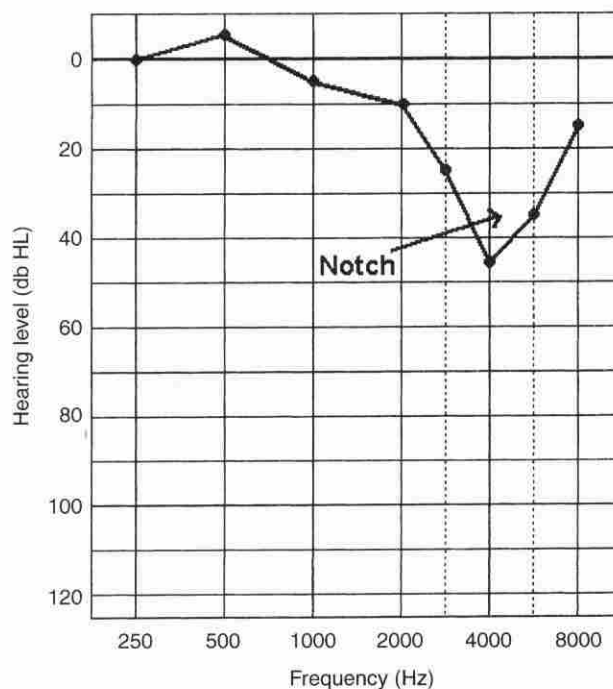


Figure 1. A high-frequency notch in the audiogram, typical of noise-induced hearing loss.

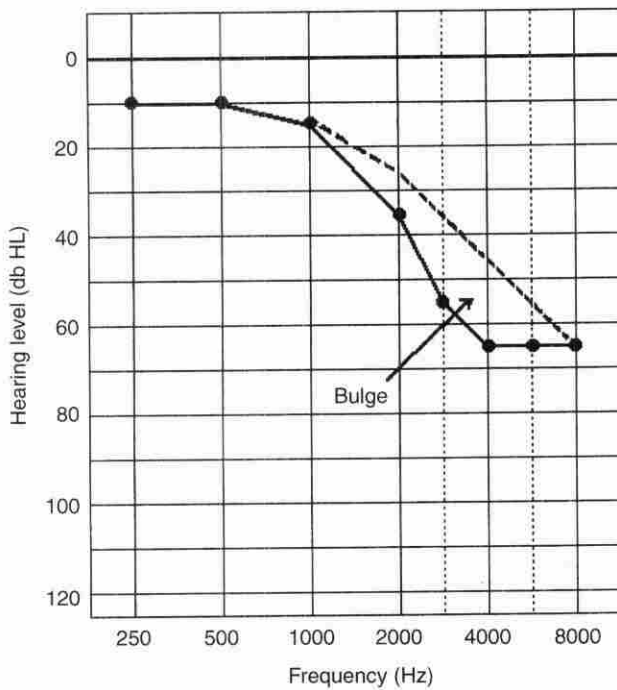


Figure 2. A bulge downwards and to the left in the audiogram, typical of noise-induced hearing loss plus presumed age-associated hearing loss (AAHL). (The dashed line indicates the median AAHL for men aged 70).

7.3. It should, however, be noted that the presence of such a notch or bulge is not pathognomonic of NIHL, as it is sometimes found or can be seen to develop in people with no significant noise exposure. Nevertheless, such a notch or bulge means a high probability of the presence of a substantial amount of NIHL if there has also been sufficient noise exposure and there is no strongly adverse or precluding other factor or diagnosis.

7.4. Likewise, the absence of a notch or bulge of sufficient size to meet R3(a) or (b) does not preclude the presence of some NIHL hidden in hearing impairments having other causation, or of NIHL having an atypical audiometric configuration. But such possibilities would generally be below the balance of probabilities. An exception might be where the size of the notch or bulge only just fails to meet the guideline, but the noise exposure had been particularly high (over 110 dB(A) NIL, for example).

7.5. Definition. A high-frequency *notch* in the air-conduction audiogram (see Note 9) that is sufficiently large to be indicative of the probable presence of NIHL is where the hearing threshold level (HTL) at 3 and/or 4 and/or 6 kHz, after any due correction for earphone type (see Note 2), is at least 10 dB greater than at 1 or 2 kHz and at 6 or 8 kHz. If an average of two or more HTL measurements can be used, the 10 dB figure may be slightly reduced (see Note 3).

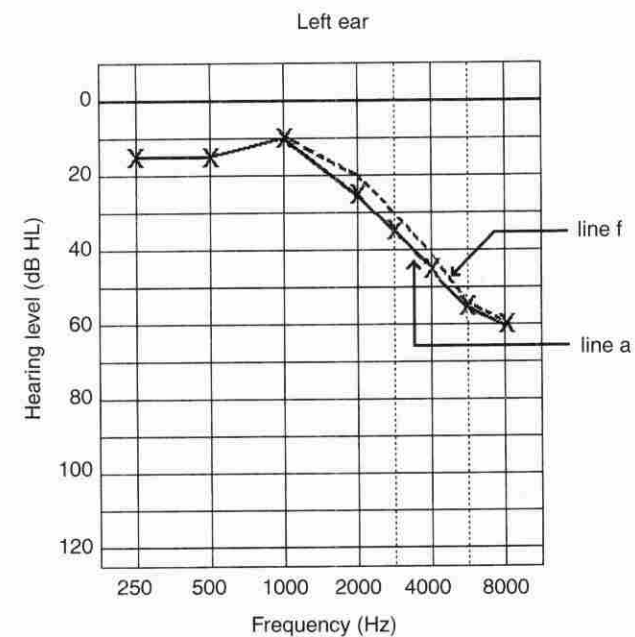
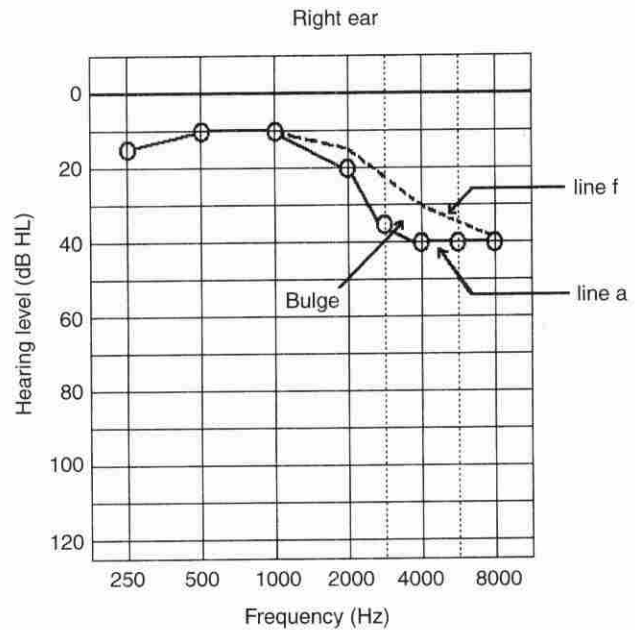


Figure 3. The worked example. (Measured hearing thresholds are shown in line a, and comparison figures of age-associated hearing loss in line f).

7.6. Definition. A high-frequency *bulge* in the air-conduction audiogram (see Note 9) that is sufficiently large to be indicative of the probable presence of NIHL is defined as follows. Such a bulge is present if the HTL at 3 and/or 4 and/or 6 kHz, after any due correction for earphone type (see Note 2), is at least 10 dB greater relative to the comparison values for age-related hearing loss (see Note 10) at corresponding

frequencies. If an average of two or more HTL measurements can be used, the 10 dB figure may be slightly reduced (see Note 3). Occasionally the bulge extends to involve 2 kHz, or even 1 kHz.

7.7. Note that the extent of the notch or bulge as defined here for diagnostic purposes does not indicate the full extent of the hearing loss caused by noise damage. For instance, the HTL values at 1 and 8 kHz are most commonly used here as the 'anchor points' for estimating the AAHL comparison values against which the measured HTLs are compared in order to identify a probable noise-induced bulge. But in fact in many cases of noise damage there is probably a component of NIHL in any hearing impairment at 1 and 8 kHz.

8. REQUIREMENT R3(b): 'AUDIOMETRIC CONFIGURATION'

8.1. If the noise exposure requirement in R2(a) is met, then audiometric requirement R3(a) is sufficiently stringent. But if the noise exposure only meets R2(b), and not R2(a), then the corresponding requirement R3(b) has to be met instead of R3(a).

8.2. Requirement R3(b) is similar to R3(a), except that the notch or bulge has to be at least 20 dB to qualify.

Modifying factors

9. MODIFYING FACTOR MF1: 'CLINICAL PICTURE'

9.1. The mode, nature and age of onset and progression of auditory symptoms, especially if prominent temporary post-exposure auditory symptoms are recalled, and the fitting and use of any hearing aid(s) should be compatible with hearing loss resulting from recurrent noise exposure. 'Prominent' here is regarded as recollection of temporary tinnitus and/or dullness of hearing lasting an hour or more. These symptoms are particularly relevant if their duration gradually increased until they were present permanently. Account needs also to be taken of any probable diagnostic competitors or additional diagnoses or noise-protective factors, although any other diagnosis may well be an additional cause of hearing loss rather than an alternative to NIHL. The examiner should indicate the extent to which any such modifying factor supports, modifies or perhaps countermands the diagnosis of NIHL.

10. MODIFYING FACTOR MF2: 'COMPATIBILITY WITH AGE AND NOISE EXPOSURE'

10.1. The hearing impairments measured should be checked for compatibility with the claimant's age, sex and estimated total amount of noise exposure, including military and non-

occupational, using the 'NPL Tables' (Robinson and Ship-ton, 1977)⁴ up to the 5th percentile values of susceptibility, or other appropriate source, such as ISO 1999: 1990.⁵ By definition, 5% of the population are even more susceptible than that, but the other evidence for the hearing impairment being due to noise and age alone should be strong for more extreme percentiles of susceptibility to be acceptable.

10.2. However, if the amount of hearing impairment is excessive in relation to the age and noise exposure (occupational, military and non-occupational), this does not necessarily negate a diagnosis of NIHL. The extra hearing impairment may well be due to a third causation, additional to NIHL and AAHL.

11. MODIFYING FACTOR MF3: 'ROBINSON'S CRITERIA'

11.1. If the diagnosis of NIHL seems borderline, the audiometric data should be checked for compatibility with Robinson's⁶ probability tests to uncover other causation. These comprise a scheme of statistical tests leading to eight criteria, each of which is expressed at two levels of probability based on the 95% and the 98% limits of normal distribution. The criteria relate to the degree of conformity of the measured audiometric configuration with the Burns and Robinson² model of NIHL, the degree of left/right asymmetry both in amount of hearing impairment and in audiometric configuration, and the calculated degree of noise susceptibility.

11.2. Where two of these criteria are exceeded, it is probable that there is some alternative or additional diagnosis present, accounting for at least part of the measured hearing impairment. Exceptions occur however, and should be argued on their merits. Where three or more of these criteria are exceeded, an alternative or additional causation becomes highly probable. Note, however, that Robinson's criterion no. 2 for asymmetry, can on its own be very helpful in defining whether measured left/right differences are to be considered acceptable or excessive, or perhaps having some particular explanation such as asymmetrical noise exposure.

11.3. Where a case passes Robinson's criteria, this only means that the data are compatible with a diagnosis of NIHL combined with presumed AAHL, without needing to postulate an additional or alternative diagnosis. They are not criteria for a diagnosis of NIHL.

12. MODIFYING FACTOR MF4: 'COMPLICATED CASES'

12.1. In some cases, there may be considerable left/right differences in the amount of hearing impairment and only one ear complies with the above-stated requirements for a diagnosis of NIHL. In such instances, the user is referred to

Note 11 for recommendations on how the guidelines should be interpreted in asymmetrical cases.

12.2. Various other aural disorders in addition to NIHL and AAHL may be present and be contributing to the hearing impairments measured. In such cases, the guidelines should not be applied rigidly. Where a person is thought to have suffered a material degree of noise-induced threshold shift, but yet does not fully qualify for that diagnosis under these guidelines, the reasons for making an exception to them should be explained in detail.

12.3 Conductive hearing loss. This is likely to affect the assessment of effective noise exposure and/or estimation of the amount of sensorineural hearing loss (see Notes 5 and 9).

Acknowledgements

We are grateful to our legal colleague, Cenric Clement-Evans, for his constructive comments at various stages in drafting these guidelines, and for his general encouragement of and collaboration with this work. We are also grateful to Diana Field for preparing the figures, and to Liz Jennings for her editorial assistance.

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Appendix A. Explanatory and further guidance notes

Note 1. Consideration of noise exposure in terms of negligence by the defendant is a separate issue, and should not be confused with diagnosis. Quantification of the amount of NIHL, disability and similar issues are also outside the scope of these guidelines.

Note 2. When Telephonics TDH-39 audiometer earphones have been used, subtract 6 dB from the measured HTL values at 6 kHz. This is to take account of the calibration artefact associated with use of those earphones.⁷ (TDH-39 earphones are the most commonly used in the UK: amongst others, they are used in most Amplivox, Bilsom (CA 850), Inter-Acoustics, Kamplex, Madsen and Peters audiometers. On the other hand, Grason-Stadler audiometers use TDH-49 or TDH-50 earphones that are free of this artefact).

Note 3. If an average of two, several or many hearing threshold measurements at the relevant frequencies in a particular ear can validly be used, the 'at least 10 dB or greater' guideline may be reduced slightly, by up to about 3 dB. In borderline cases, an average of all the audiograms available and acceptable for averaging should be used in assessing the evidence for or against the presence of a high-frequency hearing impairment, notch or bulge. To this end, if when testing the hearing of a case that seems borderline in any of these respects, it will usually help to carry out one or more re-tests at the defining frequencies with repositioning of the earphones between tests. The results of each re-test should be plotted on the audiogram and/or tabulated in the report.

Note 4. Corrections for reported use of hearing protection. In order to estimate the noise reaching the internal ear, allowances have to be subtracted from the levels of noise at work during the years in which hearing protection was understood to have been properly used. Such allowances should only be made where it is believed that the hearing protection had been used virtually all the time (in those years or for a stated proportion of them) that the individual was exposed to hazardous levels of noise.

If the particular protector used can be identified, its attenuation characteristics may be obtainable either from published data (e.g. Martin⁸) or from information provided by its manufacturer. Account has then to be taken of the evidence that hearing protectors are less effective as worn in industry than as measured in the laboratory,⁹ their real-world attenuation being about 16 dB less for earplugs and 8 dB less for earmuffs.

Where the actual protector used cannot be identified with certainty, or its attenuation characteristics are not known, recourse may be necessary to the figures in Table 1. This gives values for the mean real-world attenuation of A-weighted noise levels likely to be achieved for various classes of hearing protector.

Table 1. Realistic sound attenuation data for hearing protectors

Class of hearing protector	Real-world attenuation (dB)
Music headphones	0
Cotton wool (dry or waxed)	5
Soft plastic earplugs	10
Canal caps (suprameatal plugs on headband)	10
Personalised earmoulds	10
Glass down earplugs (e.g. Bilsom range)	15
Plastic foam earplugs (e.g. EAR range)	15
Earmuffs	20

Note 5. The presence of a conductive hearing loss may require corrections to be made to the external noise levels in order to estimate the effective levels likely to reach the internal ear (see para. 5.1.). Subtractions from the air-conduction thresholds may also be needed in order to estimate the sensorineural hearing impairment (see Note 10). Due to measurement variability and distortions, air-bone gaps may seem to differ widely (and unrealistically) between frequencies, and may also be markedly small at 2 kHz. Therefore, the best estimate of the conductive component is the air-bone gap averaged over 0.5, 1, 2 and 3 or 4 kHz, providing: (1) that in any bone-conduction tests at 4 kHz the ipsilateral ear is occluded sufficiently to prevent hearing of air-conducted sound radiated from the bone-conduction transducer; and (2) that the bone-conduction thresholds at 2 kHz are excluded from the average if the apparent air-bone gap at 2 kHz is smaller than at all the other frequencies. If the average air-bone gap is < 10 dB, corrections for conductive hearing loss should not be made.

Note 6. Various formulae^{2,4,5,10,11} predict, from the estimated noise exposure and subject's age and sex, the extent of hearing impairment to be expected in various percentiles of susceptibility.

At face value these formulae predict that even the most extremely noise-resistant percentiles would suffer some degree of NIHL. They also suggest that noise exposures of low level (e.g. low 80s in decibels) and duration (e.g. only a few years) would cause small but finite degrees of NIHL in some of those so exposed.

However, their original data sources were limited to cross-sectional studies, and the evidence for such effects is weak, being extrapolations from effects measured mostly in people with around average degrees of susceptibility and large amounts of noise exposure. The earlier work also exaggerated the apparent effect of small noise exposures. Moreover, epidemiological studies involving low level and/or short-duration and/or intermittent exposures (e.g. in forestry workers, marine engine room personnel, miners, underground railway workers, navy divers, aircraft handlers, and exposure of young persons to amplified music)

seem to indicate an occurrence of less than the expected degree of hearing loss and in smaller proportions of those exposed.

These scientific considerations have to be judged also in relation to the legal criterion of 'balance of probabilities', and to what can be regarded as a reasonably reliable single measurement in an individual ear. At 4 kHz this is considered to be about 10 dB (see para. 3.2.). According to International Standard 1999 (1990),⁵ noise exposure at 90 dB(A) for 10 years, which equates to a NIL value of 100 dB(A), causes a median NIHL of 11 dB at 4 kHz (and, incidentally about 3.5 dB in the 1, 2 and 3 kHz average). Hence, our use of the 100 dB(A) NIL value in R2(a).

Note 7. $L_{EP,d}$ noise levels below 85 dB(A) in fact cause very little NIHL. With low noise levels, the noise immission calculations tend to over-estimate the potential auditory hazard. For example, a virtually safe noise level of 80 dB(A), if heard for 20 years, would yield an apparently unsafe NIL of 93 dB(A). Therefore, it is recommended that $L_{EP,d}$ levels below 85 dB(A) should not be taken into account in estimating the total noise exposure.

Note 8. Noise exposure estimates are often rounded to the nearest whole decibel. Noise level values of 84.5–84.9 dB(A) and NIL values of 99.5–99.9 dB(A) or 89.5–89.9 dB(A) should therefore be regarded as being 85 dB(A), 100 dB(A) or 90 dB(A), respectively.

Note 9. Bone-conduction measurements are very variable and prone to calibration artifacts and distortions, such as the Carhart effect which occurs in most forms of conductive hearing loss. They should not therefore be used for judging the shape of audiograms for diagnostic purposes, although they are of course useful for identification and quantification of a conductive hearing loss. The possibility of a noise-induced notch or bulge should therefore be judged only from the shape of the air-conduction audiogram.

Note 10. Derivation of comparison values of age-associated hearing loss (AAHL). In order to obtain comparison values of AAHL in an individual ear the following procedures are recommended. See also the worked example shown in Table 4, lines a–g.

First, correct the measured hearing threshold level (HTL) values for any conductive hearing loss of ≥ 10 dB (see Note 5) and, if appropriate, for the use of TDH-39 earphones (see Note 2). Then, look at the corrected HTL values (line a) at the audiometric frequencies just above and below those most usually affected by noise. At the high frequency end of the range this is usually 8 kHz. Occasionally though, e.g. where there is a precipitous fall-off above 6 kHz, that frequency is a better indicator of the upper end of the probable AAHL pattern affecting the rest of the frequency range. The HTL at 8 kHz is therefore usually taken as the 'upper anchor point' for estimating the likely extent of AAHL in an individual ear.

Towards the lower end of the frequency range, 1 kHz is usually the best frequency to use as the 'lower anchor point'. Audiometry is fairly precise at that frequency. It is also relatively free from ambient and physiological noise masking effects and other factors which so often seem to cause 10–20 dB impairments at 0.25 and 0.5 kHz. Occasionally 0.5 or 2 kHz will be more appropriate, for example when the HTL there is more than 5 dB better than at 1 kHz.

Statistical data on AAHL are then consulted. Those shown in Tables 2 and 3 are recommended. For the plaintiff's sex and approximate age (up to 10 years above or below the actual age) the AAHL data that correspond best to the values at the two 'anchor points' (line b) are then selected (line c).

Next, calculate (line d) the misfit values. These are the differences between the statistical values (line c) and the measured HTLs at the two 'anchor points' (line b). Then (line e), interpolate misfit values for the intermediate frequencies. Go on to add these misfit values (lines d and e) to the statistical values (line c) to derive the adjusted AAHL values

(line f). The adjusted AAHL values (line f) are the ones to compare with the corrected HTLs (line a) to estimate to what extent a NIHL-like bulge may be present (line g).

Note 11. Asymmetrical hearing impairment. Robinson,⁶ in the second criterion of his scheme for identifying other causation in cases of NIHL, indicates the 'normal' limits of asymmetry in uncomplicated cases of NIHL.

In some cases of asymmetrical sensorineural hearing impairment there may be an apparent explanation. Examples include: asymmetrical noise exposure, the asymmetrical protective effect of unilateral or greater conductive hearing loss on one side or of a unilaterally poorly fitting hearing protector, asymmetrical AAHL or other asymmetrical components of the hearing impairment.

In yet other cases, there is no apparent explanation for the presence of a significant NIHL-like notch or bulge on one side only. These cases are compatible with the presence of NIHL but with varying degrees of probability. For instance if one ear meets R3(a) or R3(b), and the other ear also shows a notch or bulge but it is small-

Table 2. Typical age-associated hearing loss (AAHL) data for men*

Frequency (Hz)	Percentile	Predicted hearing threshold levels (dB) at the following ages in years												
		20	25	30	35	40	45	50	55	60	65	70	75	80
250	75	2	2	2	3	3	4	4	5	6	7	8	9	11
	50	8	8	8	8	9	10	11	12	13	14	16	17	19
	25	14	14	15	15	16	17	18	20	21	23	25	27	29
500	75	1	1	1	1	2	2	3	4	5	6	8	9	11
	50	5	5	6	6	7	8	9	10	11	13	14	16	18
	25	11	11	11	12	13	14	15	17	19	21	23	25	28
1000	75	-2	-2	-1	-1	0	0	1	2	4	5	6	8	10
	50	2	2	3	3	4	5	6	7	9	11	13	15	17
	25	7	7	7	8	9	11	12	14	16	18	21	24	27
2000	75	-1	-1	0	0	1	3	4	6	8	11	13	16	19
	50	4	4	5	6	7	9	11	13	16	19	22	26	30
	25	9	10	11	12	14	16	19	22	25	30	34	39	44
3000	75	-1	-1	0	1	3	5	7	10	14	17	21	26	31
	50	4	5	6	7	9	12	15	19	23	28	34	40	46
	25	11	11	13	15	17	21	25	30	36	42	49	57	65
4000	75	0	1	2	4	6	9	13	17	21	27	33	40	47
	50	6	7	8	11	14	18	22	28	34	41	49	58	68
	25	14	14	16	19	24	29	35	42	50	59	70	81	93
6000	75	0	1	2	4	7	10	14	19	24	30	37	45	53
	50	7	8	10	12	16	20	25	32	39	47	56	65	76
	25	16	17	19	22	27	33	39	48	57	67	79	92	105
8000	75	0	1	2	5	8	12	17	23	29	37	45	54	64
	50	8	9	11	14	18	24	30	38	46	56	67	79	92
	25	17	18	21	25	31	38	46	56	67	80	94	110	120

*Modified from International Standard ISO 7029 (1984)¹ which gives estimates for threshold shifts as a function of age in highly screened populations and is known as Database A. The above table is modified from the standard by utilising a baseline for 18-year-olds that differs from the zero value in the standard. The baseline is from the bottom line of Table 6 in Lutman and Davis (1994)¹² after subtraction of 6 dB at 6 kHz to allow for the artificial increase in hearing threshold levels in that study attributable to the use of TDH-39 earphones. Specifically, the baseline values are 7.5, 5.0, 2.0, 3.5, 4.0, 6.0, 7.0 and 7.5 dB, respectively, at 0.25, 0.5, 1, 2, 3, 4, 6 and 8 kHz. Figures in italics are derived from extrapolation beyond the age limit of 70 years used in the standard. Values > 120 dB have been truncated at 120 dB. See also Note 12.

Table 3. Typical age-associated hearing loss (AAHL) data for women*

Frequency (Hz)	Percentile	Predicted hearing threshold levels (dB) at the following ages in years												
		20	25	30	35	40	45	50	55	60	65	70	75	80
250	75	2	3	3	3	4	4	5	6	6	7	9	<i>10</i>	<i>11</i>
	50	8	8	8	8	9	10	11	12	13	14	16	<i>17</i>	<i>19</i>
	25	14	14	14	15	16	17	18	19	21	23	24	<i>27</i>	<i>29</i>
500	75	1	1	1	1	2	2	3	4	5	6	8	<i>9</i>	<i>11</i>
	50	5	5	6	6	7	8	9	10	11	13	14	<i>16</i>	<i>18</i>
	25	11	11	11	12	13	14	15	17	19	21	23	<i>25</i>	<i>28</i>
1000	75	-2	-2	-1	-1	0	0	1	2	4	5	6	<i>8</i>	<i>10</i>
	50	2	2	3	3	4	5	6	7	9	11	13	<i>15</i>	<i>17</i>
	25	7	7	7	8	9	11	12	14	16	18	21	<i>24</i>	<i>27</i>
2000	75	-1	-1	0	0	1	2	4	5	7	9	11	<i>14</i>	<i>17</i>
	50	4	4	4	5	6	8	10	12	14	17	20	<i>23</i>	<i>27</i>
	25	9	9	10	11	13	15	17	20	23	26	30	<i>34</i>	<i>39</i>
3000	75	-1	-1	0	1	2	3	5	7	9	12	15	<i>18</i>	<i>21</i>
	50	4	4	5	6	8	9	12	14	17	21	24	<i>28</i>	<i>33</i>
	25	10	11	11	13	15	17	20	23	27	32	36	<i>42</i>	<i>48</i>
4000	75	0	1	1	2	4	5	7	10	12	15	19	<i>23</i>	<i>27</i>
	50	6	6	7	9	10	13	15	18	22	26	30	<i>35</i>	<i>41</i>
	25	13	14	15	16	19	22	25	29	34	39	45	<i>51</i>	<i>58</i>
6000	75	1	1	2	3	5	7	10	13	17	21	25	<i>30</i>	<i>36</i>
	50	7	8	9	10	13	16	19	23	28	34	39	<i>46</i>	<i>53</i>
	25	15	16	17	20	23	26	31	36	43	50	57	<i>66</i>	<i>75</i>
8000	75	0	1	2	3	6	8	12	16	20	25	31	<i>37</i>	<i>44</i>
	50	8	8	10	12	15	18	23	28	34	41	48	<i>56</i>	<i>65</i>
	25	17	18	20	23	26	31	37	44	51	60	70	<i>80</i>	<i>92</i>

*Modified from International Standard ISO 7029 (1984)¹ which gives estimates for threshold shifts as a function of age in highly screened populations and is known as Database A. The above table is modified from the standard by utilising a baseline for 18-year-olds that differs from the zero value in the standard. The baseline is from the bottom line of Table 6 in Lutman and Davis (1994)¹² after subtraction of 6 dB at 6 kHz to allow for the artificial increase in hearing threshold levels in that study attributable to the use of TDH-39 earphones. Specifically, the baseline values are 7.5, 5.0, 2.0, 3.5, 4.0, 6.0, 7.0 and 7.5 dB, respectively, at 0.25, 0.5, 1, 2, 3, 4, 6 and 8 kHz. Figures in italics are derived from extrapolation beyond the age limit of 70 years used in the standard. Values > 120 dB have been truncated at 120 dB. See also Note 12.

ler than the 10 dB or 20 dB required, then the probability of NIHL is still high. If one ear is markedly better at high frequencies and shows a significant notch or bulge, but the worse ear shows little or no trace of such, then there is still a more-likely than-not probability of NIHL: the greater hearing impairment in the worse ear may be due to some unidentified cause additional to NIHL and ordinary AAHL, that additional disorder having hidden or obliterated the noise-induced notch or bulge. In other cases there is not much difference between the two ears at high frequencies but, without apparent explanation, only one ear shows a significant notch or bulge and the other shows little or no trace of one: such cases should be regarded as very borderline and be decided on the strength of other evidence (e.g. severity of noise exposure or of temporary postexposure symptoms). Finally, if only the worse ear at high frequencies shows a significant notch or bulge, and there is little or no trace

of NIHL in the better ear, then there is only a possibility of NIHL, not a probability.

Note 12. ISO 7029¹ includes a baseline term to represent the median hearing threshold level (HTL) of 18-year-olds, although the standard suggests that for practical purposes this may be assumed to be zero. Since the publication of the standard, it has become evident that values greater than zero are appropriate for representative populations screened to exclude otological disorder and noise exposure. The formulation within ISO 7029 entails that the distribution of HTLs is not fixed, but varies according to the median value. Hence, incorporation of a nonzero baseline also increases the spread of the distribution. A revision of ISO 7029 is being prepared and is currently at a final draft stage. The revised version will remove the dependence of the spread on the baseline value. Hence, the values in Tables 2 and 3 have been calculated without this dependence, to conform to the forthcoming version of the standard.

Appendix B. Worked example of application of requirement R3(a)

Take a hypothetical claimant, aged 57. He had a total of 23 years of unprotected exposure to high levels of noise in the steel industry, which would easily meet qualifying requirement R2(a), making R3(a) the relevant guideline for looking at his audiogram. His hearing was measured with an audiometer employing TDH-39 earphones. There was no conductive hearing loss.

The calculations to see whether or not there is a high-frequency audiometric bulge that meets the NIHL diagnostic guidelines are set out in Table 4 for each ear separately.

DIAGNOSTIC CONCLUSIONS

In the table for the right ear, the better-hearing ear, in line g there is a significant bulge of +13 dB at 3 kHz and of +10 dB at 4 kHz. But there is only a small, nonsignificant trace of a bulge in the worse-hearing ear of only +5 to +3 dB from 2 to 4 kHz in line g. The pattern of asymmetry (see Note 11) is such that the probable diagnosis is of NIHL and AAHL in both ears, together with an additional hearing loss of uncertain causation on the left which has obscured most of the noise damage on that side.

The measured thresholds corrected at 6 kHz (lines a in Table 4) and the adjusted AAHL values (lines f) are illustrated in Fig. 3.

Table 4. Worked example: calculations for the identification of possible presence of noise-induced hearing loss

Line		Hearing threshold levels (dB) at the audiometric frequencies (kHz)							
		0.25	0.5	1	2	3	4	6	8
Right ear	a HTL measured* and corrected	15	10	10	20	35	40	39†	40
	b HTL at selected 'anchor points'			10					40
	c Selected AAHL statistics‡			8	13	20	28	32	38
	d Misfit values at 'anchor points' (line b minus line c)			+2					+2
	e Interpolated misfit values				+2	+2	+2	+2	
	f Adjusted AAHL values (line c plus lines d and e)			10	15	22	30	34	40
	g Audiometric bulge (line a minus line f)			0	+5	+13	+10	+5	0
Left ear	a HTL measured* and corrected	15	15	10	25	35	45	54†	60
	b HTL at selected 'anchor points'			10					60
	c Selected AAHL statistics‡			13	21	30	40	51	54
	d Misfit values at 'anchor points' (line b minus line c)			-3					+6
	e Interpolated misfit values				-1	+1	+2	+4	
	f Adjusted AAHL values (line c plus lines d and e)			10	20	31	42	55	60
	g Audiometric bulge (line a minus line f)			0	+5	+4	+3	-1	0

*Corrected for any conductive hearing loss of ≥ 10 dB (see Note 5).

†Corrected by 6 dB for TDH-39 earphone calibration artefact (see Note 2).

‡ From Table 2, age 55, median values.

§ From Table 2, age 55, 75th percentile values.

Appendix F: American College of Occupational and Environmental Medicine (ACOEM) Guidelines



AMERICAN COLLEGE OF
OCCUPATIONAL AND
ENVIRONMENTAL MEDICINE

Noise-induced Hearing Loss

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Since the publication in 1989 of an earlier position statement by the American College of Occupational and Environmental Medicine (ACOEM),¹ noise-induced hearing loss remains one of the most prevalent occupational conditions, partly due to the fact that noise is one of the most pervasive occupational hazards found in a wide range of industries. ACOEM believes that occupational clinicians need to become increasingly proficient in the early detection and prevention of noise-induced hearing loss. This requires clarification of current best practices, as well as additional research into certain aspects of noise-induced hearing loss that remain poorly understood.

Based on current knowledge, and to promote improved surveillance and research for this condition, ACOEM proposes the following update of previous position statements regarding the distinguishing features of occupational noise-induced hearing loss.

Definition

Occupational noise-induced hearing loss, as opposed to occupational acoustic trauma, is hearing loss that develops slowly over a long period of time (several years) as the result of exposure to continuous or intermittent loud noise. Occupational acoustic trauma is a sudden change in hearing as a result of a single exposure to a sudden burst of sound, such as an explosive blast. The diagnosis of noise-induced hearing loss is made clinically by a medical professional and should include a study of the noise exposure history.

Characteristics

The principal characteristics of occupational noise-induced hearing loss are as follows:

- It is always sensorineural, affecting hair cells in the inner ear.
- Since most noise exposures are symmetric, the hearing loss is typically bilateral.
- Typically, the first sign of hearing loss due to noise exposure is a “notching” of the audiogram at 3000, 4000, or 6000 Hz, with recovery at 8000 Hertz (Hz).² The exact location of the notch depends on multiple factors including the frequency of the damaging noise and the length of the ear canal. Therefore, in early noise-induced hearing loss, the average hearing thresholds at 500, 1000, and 2000 Hz are better than the average at 3000, 4000, and 6000, and the hearing level at 8000 Hz is usually better than the deepest part of the “notch.” This “notching” is in contrast to age-related hearing loss, which also produces high frequency hearing loss, but in a down-sloping pattern without recovery at 8000 Hz.³
- Noise exposure alone usually does not produce a loss greater than 75 decibels (dB) in high frequencies, and 40 dB in lower frequencies. However, individuals with superimposed age-related losses may have hearing threshold levels in excess of these values.
- The rate of hearing loss due to chronic noise exposure is greatest during the first 10-15 years of exposure, and decreases as the hearing threshold increases. This is in contrast to age-related loss, which accelerates over time.
- Most scientific evidence indicates that previously noise-exposed ears are not more sensitive to future noise exposure and that hearing loss due to noise does not progress (in excess of what would be expected from the addition of age-related threshold shifts) once the exposure to noise is discontinued.⁴
- In obtaining a history of noise exposure, the clinician should keep in mind that the risk of noise-induced hearing loss is considered to increase significantly with chronic exposures above 85 dBA for an 8-hour time-weighted average (TWA). In general, continuous noise exposure over the years is more damaging than interrupted exposure to noise which permits the ear to have a rest period. However, short exposures to very high levels of noise in occupations such as construction or firefighting may produce significant loss,^{5,6} and measures to estimate the health effects of such intermittent noise are lacking. When the noise exposure history indicates the use of hearing protective devices, the clinician should also keep in mind that the real world attenuation provided by hearing protectors may vary widely between individuals.⁷

The Occupational Physician as Professional Supervisor of a Hearing Conservation Program

ACOEM believes that occupational physicians can play a critical role in the prevention of noise-induced hearing loss by serving as professional supervisors of hearing conservation programs. The Council on Accreditation of Occupational Hearing Conservation (CAOHC) offers a course for professional supervisors.

The responsibilities of such a supervisor include supervision of an audiometric technician, review of problem audiograms and determination of whether there is a need for additional evaluation, determining the work-relatedness of a threshold shift, revision of an audiometric baseline, and evaluation of the effectiveness of the hearing conservation program.⁸ The professional supervisor should be an advocate for the “hearing health” of noise-exposed persons, and work to ensure that noise exposures are minimized both at work and during recreational activities, through avoidance of excessive noise and proper use of hearing protection when necessary.

Additional Considerations in the Evaluation of the Worker with Suspected Noise-induced Hearing Loss

Clinicians evaluating cases of possible noise-induced hearing loss should keep in mind the following clinical concerns:

- While noise-induced hearing loss is typically bilateral, asymmetric sources of noise such as sirens or gunshots can produce asymmetric loss. When evaluating cases of asymmetric loss, referral to rule out a retro-cochlear lesion is first warranted before attributing the loss to noise.
- Co-exposure to ototoxic agents such as solvents, heavy metals, and tobacco smoke may act in synergy with noise to cause hearing loss.⁹ However, the role of such cofactors – as well as the role of cardiovascular disease, diabetes, and neurodegenerative diseases – remains poorly understood. Individual susceptibility to the auditory effects of noise varies widely, but the biological basis for this also remains unclear.¹⁰
- Over a period of years of prolonged noise exposure, hearing loss due to noise expands to involve additional frequencies. This, together with the effects of aging, may reduce the prominence of the “notch.” Therefore, in older individuals, the effects of noise may be difficult to distinguish from presbycusis without access to previous audiograms.¹¹
- Individuals with noise-induced hearing loss may experience significant morbidity due to hearing loss, concomitant tinnitus, and impaired speech discrimination. On the job, such hearing loss can impact worker communication and safety. Other conditions associated with hearing loss may be depression, social isolation,¹² and increased risk of accidents.¹³ Workers with evidence of hearing loss require an individualized approach that takes into account the need to communicate safely and effectively, and the need for protection from additional damage due to noise.
- Since the loss of hearing due to noise is not reversible, early detection and intervention is critical to improving prevention of this condition. A 10 dB confirmed threshold shift from baseline in pure tone average at 2000, 3000, and 4000 Hz (OSHA standard threshold shift), while not necessarily resulting in significant impairment, is an important early indicator of permanent hearing loss. Therefore, individuals in hearing conservation programs who exhibit such 10 dB threshold shifts on serial audiometric testing should be carefully evaluated and counseled regarding avoidance of noise and correct use of personal hearing protection.
- Age correction of audiograms is a method of age standardization allowing comparisons of hearing loss rates between populations. Applying age correction to the surveillance audiograms of a noise-exposed population results in fewer confirmed 10 dB shifts being reported. Therefore, when applying age correction to the audiometric results of an individual who has experienced a threshold shift, the clinician should consider whether in that individual a preventable noise component of hearing loss is playing a role.

Research Priorities

In an effort to shed light on some of the gaps in the current knowledge, ACOEM proposes the establishment of a research agenda for noise-induced hearing loss, and recommends research be conducted in the following areas:

- the relationship between specific noise exposures and risk of hearing loss, including impact noise, fluctuating noise, and noise at different frequencies, in order to improve protective exposure guidelines for noise exposure;
- early indicators of hearing loss, including the use of emerging audiologic technology such as otoacoustic emissions;
- the role of cofactors in hearing loss, including solvents, metals, vibration, heat, and carbon monoxide;
- the biology of noise-induced hearing loss, including the role of antioxidant compounds in prevention and recovery and whether noise damage continues to progress after noise exposure stops;
- individual susceptibility to noise-induced hearing loss, including the molecular basis for such susceptibility;
- the relationship of noise-induced hearing loss to other medical conditions, including cardiovascular disease, diabetes, and neurodegenerative diseases including age-related hearing loss;
- the impact of noise-induced hearing loss on individuals and their families and the development of rehabilitation strategies to maximize function and minimize disability;
- the behavioral aspects of noise avoidance and protection, including the effectiveness of training programs for hearing loss prevention.

Evaluation of the Effectiveness of a Hearing Conservation Program

To date, there is no universally accepted method of evaluating the effectiveness of a hearing conservation program. Hearing conservation programs include aspects of administrative controls, engineering controls, audiometric surveillance, and training. Occupational physicians can actively participate with employers in improving all these aspects of hearing conservation programs through ongoing evaluation of program outcomes and processes.

Acknowledgements

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Appendix G: Sample ISO 1999 calculations

The following tables are calculated from tables in ISO 1999. The example used is that of a person 60 years of age, with 10-40 years' (in decades) exposure at each of four noise levels.

They are presented separately for men and women. Note, however, that only the age-related hearing loss varies by gender.

They are derived from Database A – which summarises data from people without otological abnormalities – the end result being that the calculated figures represent total hearing loss to be expected from age and noise exposure. Both mean (i.e. 50th percentile) and 90th percentile calculations are presented.

In addition to showing the total hearing loss in dB HL, also shown is the percentage loss of hearing (PLH) for both the hearing loss as indicated and also the age-corrected PLH – using the same percentile age data.

It is recommended that the age-adjusted PLH for men be used as an estimate of the PLH attributable to noise-induced hearing loss for both genders, since any gender difference between age-corrected estimates of NIHL is merely an artefact of the PLH scale.

Figure 3 in the main body of the Guide is a graphical representation of the age-adjusted PLH for men.

Combination of noise and age only for men (at 60 years)
50th percentile age and noise data

MEN	10 years' exposure; thresholds in dB; 50th percentile data								PLH		
	500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted		
	85	6	7	10	13	23	32	34	2	1	
	90	6	7	10	14	27	36	37	3	2	
	95	6	9	13	17	33	43	42	5	4	
	100	10	13	16	19	42	52	49	8	7	
	20 years' exposure; thresholds in dB; 50th percentile data										
		500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted	
	85	6	7	10	13	23	33	34	2	1	
	90	6	7	11	16	28	38	38	3	2	
Average	95	6	10	15	20	36	46	44	6	5	
daily noise	100	11	15	21	26	47	56	52	12	11	
exposure		30 years' exposure; thresholds in dB; 50th percentile data									
dB(A)		500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted	
8 hours/day,											
5	85	6	7	10	13	23	33	34	2	1	
days/week,	90	6	7	12	17	29	39	39	4	3	
50	95	7	10	16	23	38	47	45	7	6	
weeks/year	100	12	16	24	31	49	58	53	14	13	
		40 years' exposure; thresholds in dB; 50th percentile data									
		500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted	
	85	6	7	10	14	24	33	35	2	1	
	90	6	7	12	17	30	40	39	4	3	
	95	7	10	17	25	39	48	46	8	7	
	100	13	17	26	34	52	59	54	15	14	

**Combination of noise and age only for men (at 60 years)
90th percentile age and 90th percentile noise data**

MEN	10 years' exposure; thresholds in dB; 90th percentile data								PLH	
	500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted	
85	18	19	24	30	45	59	64	14	2	
90	18	19	26	34	50	63	68	17	5	
95	19	22	31	39	58	70	73	23	11	
100	25	29	38	46	69	78	80	33	20	
	20 years' exposure; thresholds in dB; 90th percentile data									
	500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted	
85	18	19	25	31	46	59	64	15	2	
90	18	19	27	35	52	65	69	18	6	
95	19	23	33	42	62	72	75	25	13	
100	26	32	42	53	75	80	82	38	26	
	30 years' exposure; thresholds in dB; 90th percentile data									
	500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted	
85	18	19	25	31	47	60	65	15	3	
90	18	19	28	36	54	65	69	19	6	
95	19	23	34	44	64	73	76	27	14	
100	27	33	45	56	78	84	84	42	29	
	40 years' exposure; thresholds in dB; 90th percentile data									
	500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted	
85	18	19	25	31	47	60	65	15	3	
90	18	19	28	37	54	66	69	19	7	
95	19	24	35	46	66	75	76	28	16	
100	27	35	47	59	81	85	85	44	32	

**Combination of noise and age only for women (at 60 years)
50th percentile age and noise data**

WOMEN	10 years' exposure; thresholds in dB; 50th percentile data								PLH	
	500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted	
85	6	7	9	12	16	20	23	0	0	
90	6	7	10	13	20	26	27	1	1	
95	6	9	12	16	27	33	33	2	2	
100	10	13	15	18	36	43	40	5	5	
	20 years' exposure; thresholds in dB; 50th percentile data								Total HL	Age-adjusted
	500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted	
85	6	7	9	12	17	21	23	0	0	
90	6	7	11	15	22	27	28	1	1	
Average daily noise exposure dB(A) 8 hours/day, 5 days/week, 50 weeks/year	95	6	10	15	19	30	36	34	3	3
	100	11	15	21	26	42	47	43	9	9
	30 years' exposure; thresholds in dB; 50th percentile data								Total HL	Age-adjusted
	500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted	
85	6	7	9	12	17	21	23	0	0	
90	6	7	11	16	23	28	28	1	1	
95	7	10	16	22	33	38	36	5	5	
100	12	16	23	30	44	50	45	11	11	
	40 years' exposure; thresholds in dB; 50th percentile data								Total HL	Age-adjusted
	500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted	
85	6	7	10	13	17	22	24	0	0	
90	6	7	12	16	24	29	29	1	1	
95	7	10	17	24	34	39	37	5	5	
100	13	17	25	33	47	52	46	13	13	

**Combination of noise and age only for women (at 60 years)
90th percentile age and 90th percentile noise data**

WOMEN	10 years' exposure; thresholds in dB; 90th percentile data								<i>PLH</i>	
	500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted	
85	18	19	22	26	34	40	48	8	3	
90	18	19	24	30	40	46	53	11	6	
95	19	22	29	35	49	54	59	18	12	
100	25	29	36	43	61	65	68	28	23	
20 years' exposure; thresholds in dB; 90th percentile data										
	500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted	
85	18	19	23	27	35	41	48	9	3	
90	18	19	25	31	42	48	54	12	7	
95	19	23	31	38	53	58	61	20	15	
100	26	32	41	50	68	68	71	35	29	
30 years' exposure; thresholds in dB; 90th percentile data										
Average daily noise exposure dB(A) 8 hours/day, 5 days/week, 50 weeks/year	500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted	
	85	18	19	23	27	35	41	49	9	3
	90	18	19	26	32	44	48	54	13	8
	95	19	23	32	41	56	59	63	22	17
	100	27	33	43	53	72	73	74	38	32
40 years' exposure; thresholds in dB; 90th percentile data										
	5,00	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted	
85	18	19	23	27	35	41	49	9	3	
90	18	19	26	33	44	49	54	14	8	
95	19	24	33	42	58	61	63	23	18	
100	27	35	46	56	75	75	75	41	36	





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