Assessment of Occupational Noise-Induced Hearing Loss for ACC

A PRACTICAL GUIDE FOR OTOLARYNGOLOGISTS

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INTRODUCTION

This Workbook 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 claimant-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.

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The Workbook has been endorsed by the New Zealand Society of Otolaryngology, Head and Neck Surgery. (*date*?)

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Note: There is an electronic version of this document, which will be updated from time to time, available at: *link*

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 claimant contributed to the injury. A claim can be lodged regardless of the claimant'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 to 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 which involves only an allowance which is not subject to taxation (such as volunteer firemen, prisoners involved in work schemes) is not covered.

You can see from this 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
- 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.

Accidents

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

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 claimants who lodged a claim on or after 1st July 2010, a 6% hearing loss threshold for cover applies. That is, the amount of hearing loss attributed to occupational noise-induced hearing loss (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 claimants 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 1999[1]. Under these regulations, the percentage loss of hearing 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 scale[2] is presented at: link.

Accident Compensation (Apportioning Entitlements for Hearing Loss) Regulations 2010[3] 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. Both ACC and the Ministry of Health payments 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 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.

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[1] Link to 1999 regulations

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

[3] Link to 2010 regulations

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, that is, put in place a process or mechanism that keeps employees away from the hazard. If this can't reasonably be done, then 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 dBA 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 protection[4].

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[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/idcplg?IdcService=GET_FILE&dID=4620&dDocName=WIM2_065096&allowInterrupt=1

Assessment Issues

Medical Council of New Zealand

The Medical Council has developed guidelines for doctors carrying out medical assessments for third parties[5]. 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 claimant 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 Council[6].

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.

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[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)

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 remain impartial.

(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 entity[7]), 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 *can be managed* 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

[7] Trust or company

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

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

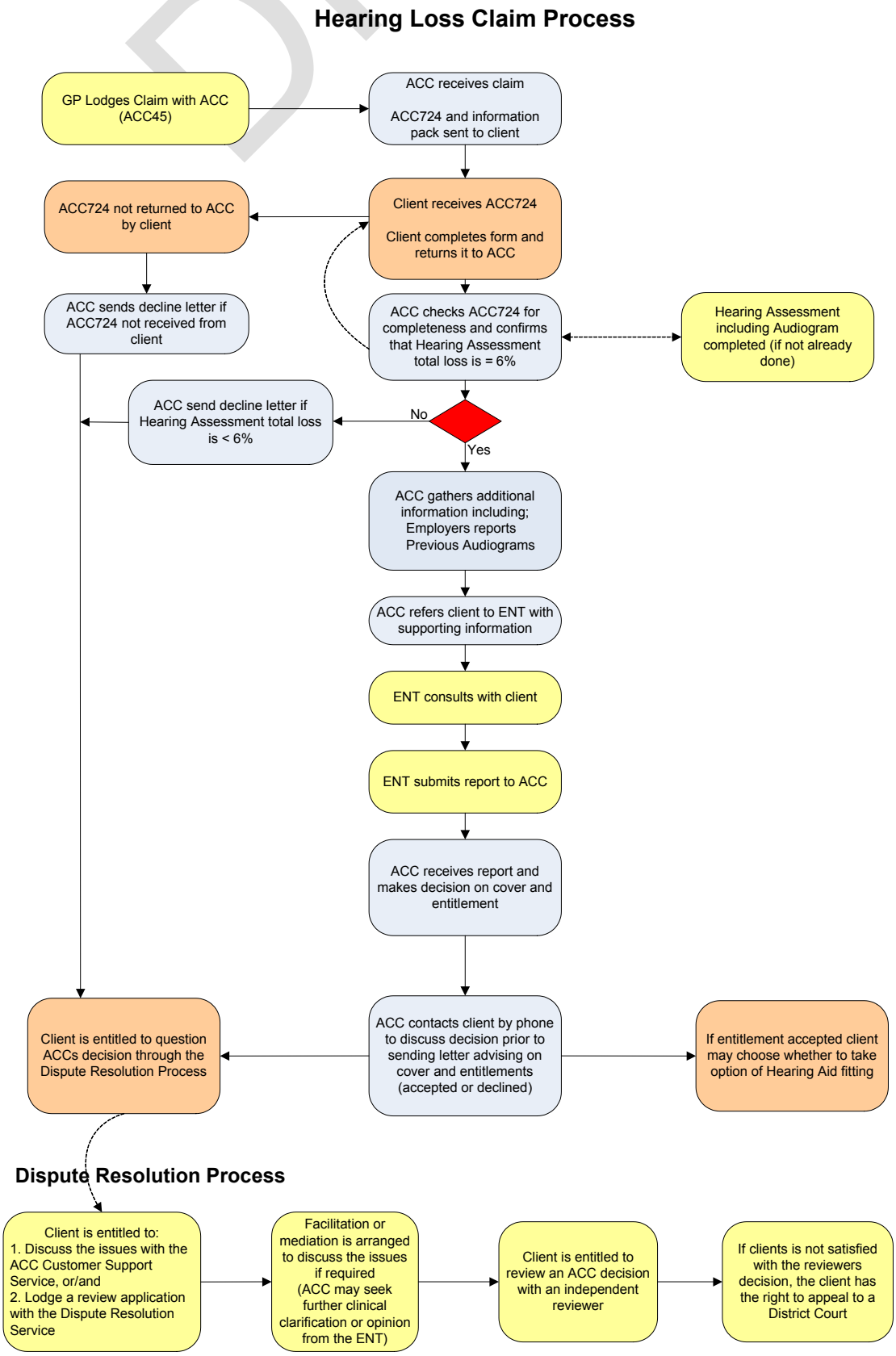
Your role is to assess the gathered information, including objective and clinical findings in the light of your professional knowledge in order to reach an opinion. You are not required to make a decision on the claim but your opinion will be taken into account by ACC in their decision making.

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 claimant 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 claimant ceased work may be useful for tracking the progression of a claimant's hearing loss.
- Individuals working in ongoing noise should have a more contemporaneous 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 claimant 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



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 fie 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 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:
Link to client FAQs

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 Workbook, ACC commissioned a series of evidence reviews to summarise the current state of knowledge in a range of related areas. Each review was peer reviewed by several international experts.
A summary of each paper with recommendations follows.

The reviews commissioned comprise:

Guideline for diagnosing occupational noise-induced hearing loss

- ***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.

- ***Part 2: Other risk factors impacting on hearing loss***
  Zhi-ling Zhang, ACC
  This review covers risks of developing hearing loss associated with agents other than noise.

- ***Part 3: Audiometric standards***
  Suzanne Purdy, University of Auckland, & 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.

Summaries of the three evidence reviews follow.

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.

The relationships between noise exposure (level and duration) and hearing loss have been looked at for 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 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, 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 dBA, 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 dBA.

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. This 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: Other risk factors impacting on hearing loss

Zhi-ling Zhang, Senior Research Adviser, ACC

Practically, noise exposure needs to be considered the highest 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 of 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 a 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 cause 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-occupational-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 substantive exposure has occurred, a separate claim might be expected.

Guideline for diagnosing occupational noise-induced hearing loss

Part 3: Audiometric standards

Suzanne Purdy, University of Auckland, &
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 shall 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 µPa)**	
	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 k	40	**19**
4 k	47	**15**
8 k	46	**22**

Calibration

Audiometers shall be of Type 1, as specified by IEC 60645-1. Formal calibration of all audiometric test equipment shall 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 will be undertaken by an accredited testing laboratory with full, documented traceability to National Standards. Formal calibration shall 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:
  Prof Peter Thorne
  Dr 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:
  Dr 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 ACC form 723 (see Appendix A), which is available for either manual or electronic use, or using the same headings and order as form 723. 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 724 (see Appendix B) and your own verbal history. It is expected that you will ask questions based on information provided in form 724 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.

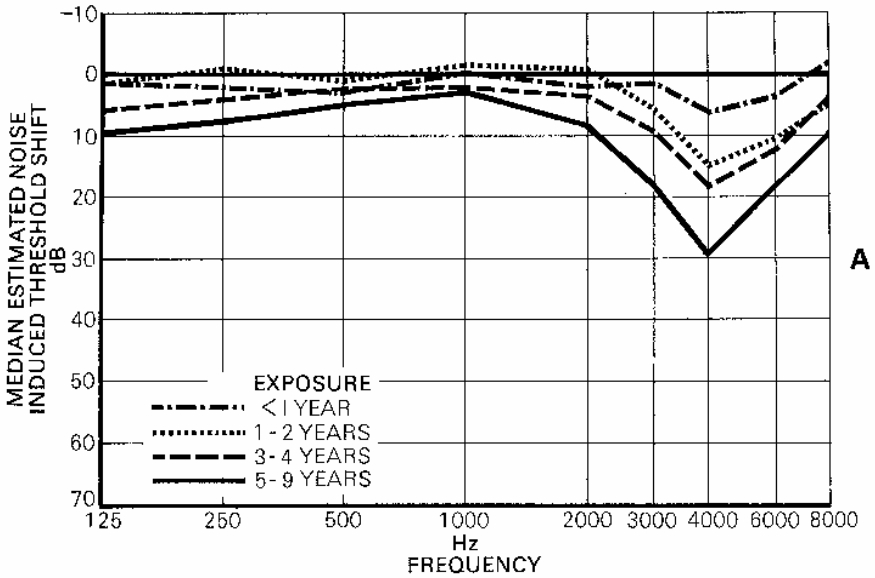
Occupational noise exposure
This is of paramount importance in providing an evidence-based opinion. In all cases other than the most obvious, it is essential to extract details of the client's work environment to enable you to establish the probable exposure levels.

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 legislative section, pp …).

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.



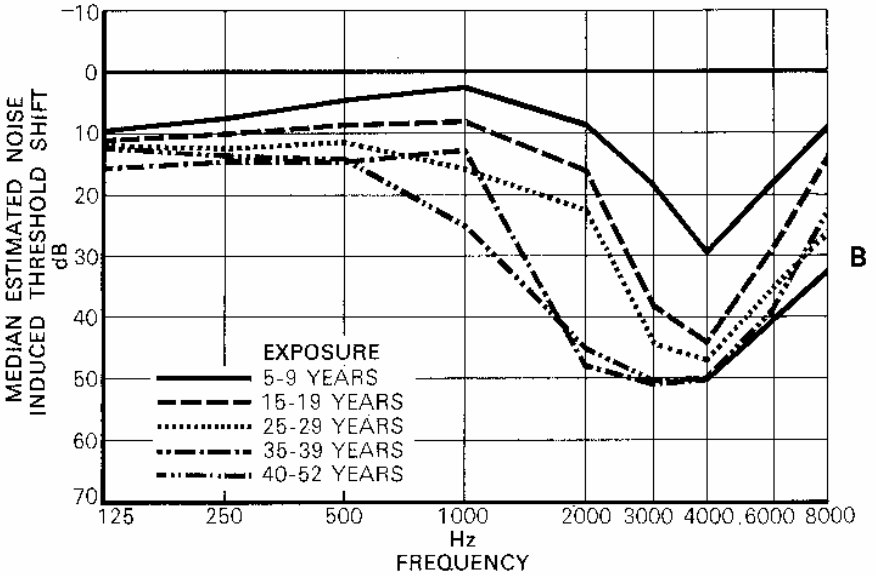


Figure 1. Audiograms showing onset and progression of NIHL in female jute weavers[8] exposed to noise levels averaging 100 dBA

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.

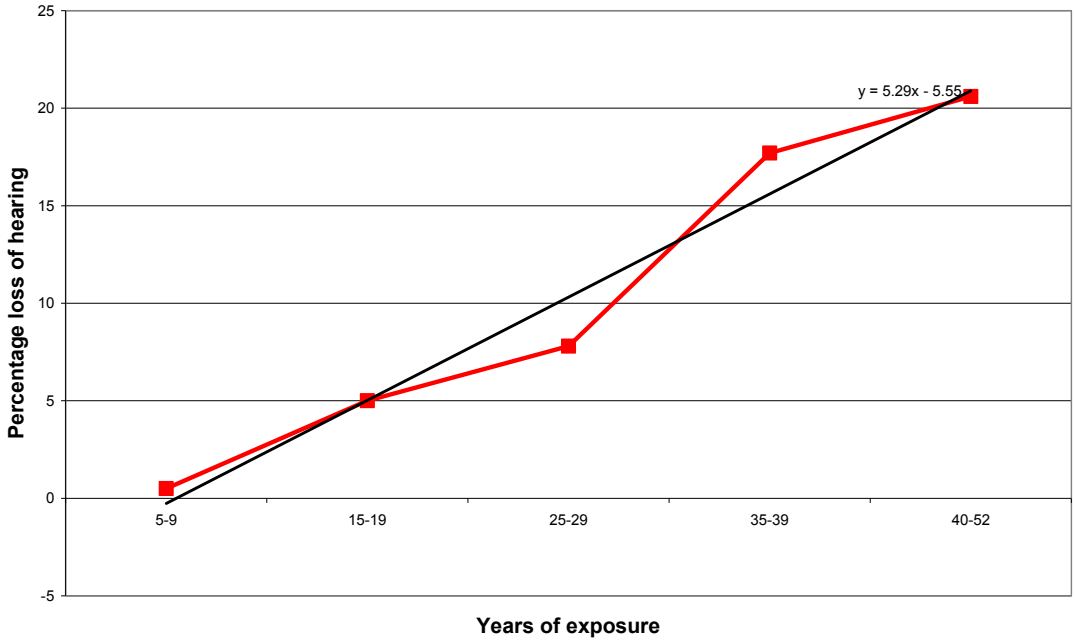


Figure 2. Progression of hearing loss, expressed as a percentage, as a function of years of exposure for female jute weavers as in Figure 1 – linear trend line superimposed.

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

[8] Taylor W, Pearson J, Mair A and Burns W. Study of noise and hearing in jute weaving. *Journal of the Acoustical Society of America* 1965;38:113

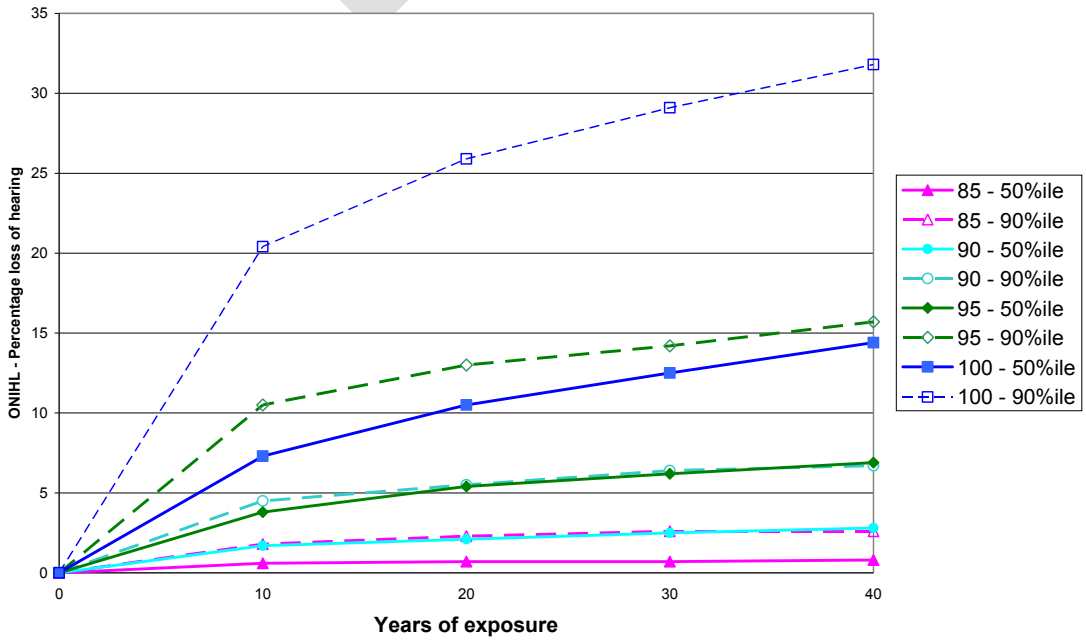


Figure 3. Progression of hearing loss, expressed as a percentage, as a function of years of exposure at various noise levels for mean data for 60-year-old men with standard age adjustments, calculated from ISO 1999 (see Appendix G)

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 hearing[14]
- the University of Auckland report on prevention of hearing loss[9]
- Department of Health historical noise levels[10]
- various other databases of noise levels
- papers on specific industries such as metal manufacturing[11], farming[12], and sheep shearing[13].

Information on the impact of hearing protection is given in:

- David McBride's evidence review of the types of noise and their effects on hearing[14]
- the University of Auckland report on prevention of hearing loss[15]

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[9] 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

[10] Department of Health, Summary of Noise Surveys, 1986

[11] Welch D, John G, Grynevych A, Thorne P. Report on noise and hearing loss in the metal manufacturing industry. Prepared for the Accident Compensation Corporation. Auckland UniServices, December 2009

[12] 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

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

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

[15] 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

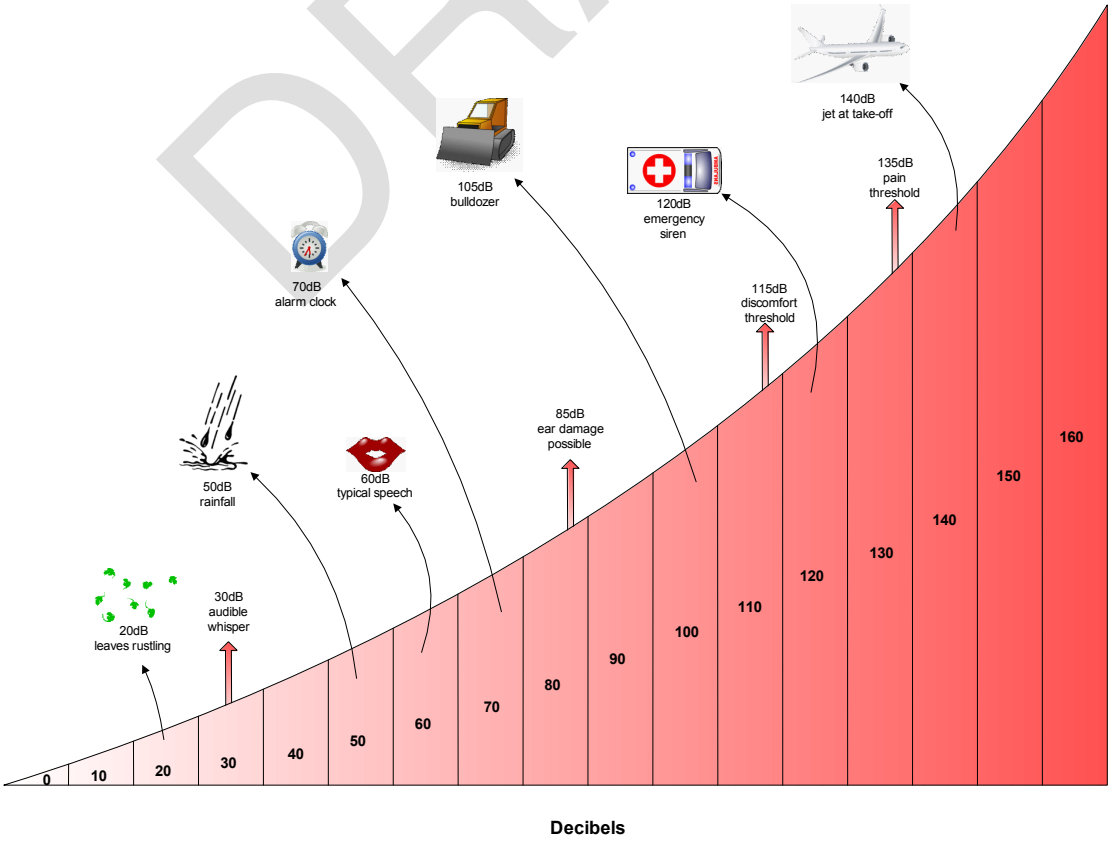

Figure 4. Typical noise levels in New Zealand THIS WILL INCLUDE ACTUAL WORKPLACE NOISE LEVELS (to be replaced)

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 McBride[16]. 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

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

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 McBride[17].

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.

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

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

Aminoglycoside antibiotics	Particularly streptomycin, neomycin, kanamycin, gentamycin, vancomycin, tobramycin. 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, 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-moderate (usually flat) hearing loss, but effects may be reversible if treatment is discontinued. May also have CNS effects.
Quinine	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 when given in large doses or in cases of renal failure can cause hearing loss. This may be reversible.

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 Zhang[18] (see pages x to y).

A review in 1997[19] 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	
Toluene	Manufacture of chemicals, paint and lacquers, pharmaceuticals, rubber products, fibreglass products, food containers, carpet; oil refining, aircraft operation, boat building
Styrene	

[18] Guideline for diagnosing occupational noise-induced hearing loss. Part 2: Zhang Z. Other risk factors impacting on hearing loss. Report for ACC, November 2010

[19] 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

Xylene	
Dimethylformamide	Manufacture of clothing and textiles
Dinitrobenzene	Dry cleaning Paint manufacture Manufacture of rubber items
Gases	
Carbon monoxide	Fuel gas mixtures (water gas, blast furnace gas, producer gas, coal gas or illuminating gas); chemical manufacturing; mining and processing of nickel, cobalt; metal production (e.g. steel)
Heavy metals	
Cadmium Lead Mercury	Manufacture of alkaline batteries; manufacture of pigments, coatings, and platings; and plastics Construction, mining, manufacturing (batteries, ammunition); formerly paint, ceramics, pipes Fluorescent lightbulbs, dental amalgam, solder, thermometers, detonators

(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's[20] 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 x 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.

(5) Summary and recommendations

Summary of hearing loss

Is the pattern of hearing loss typical of NIHL?

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

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"[21] (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 shouldered[22]. 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 Greville[23], 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 purposes[24], 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

[21] American College of Occupational and Environmental Medicine's Noise and Hearing Conservation Committee. Noise induced hearing loss, 2002

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

[23] Greville A. The NAL percentage loss of hearing scale. ACC, February 2010

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

- 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 F)
- 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 & Williams[25] discusses issues such as bone conduction reliability.

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:

- McBride[26]
- Dobie[27]
- 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 claimant'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".

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

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

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

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.

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 claimant'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 claimant 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 yy), 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 sole 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.

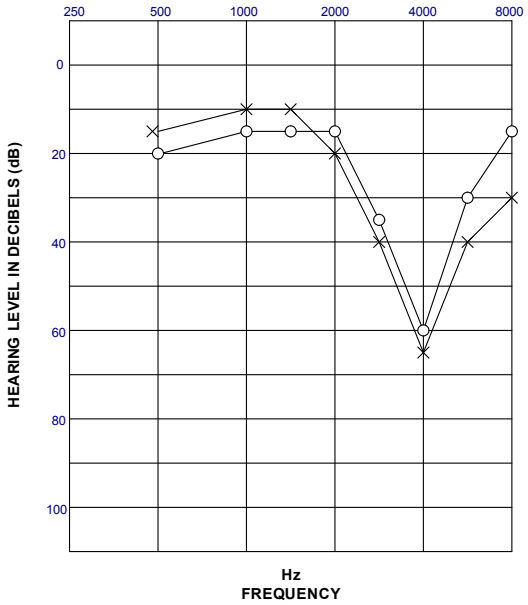
Non-work noise
Nil of note.

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:

- 7.2% total hearing loss (Right: 6.7%, 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	20	15	15	15	35	60	30	15	6.7
Left	15	10	10	20	40	65	40	30	8.4
Binaural									7.2

Conclusion

Total hearing loss	7.2
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.
- Apart from the small degree of hearing loss at 500 Hz on the right, 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 taking 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 sole 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.

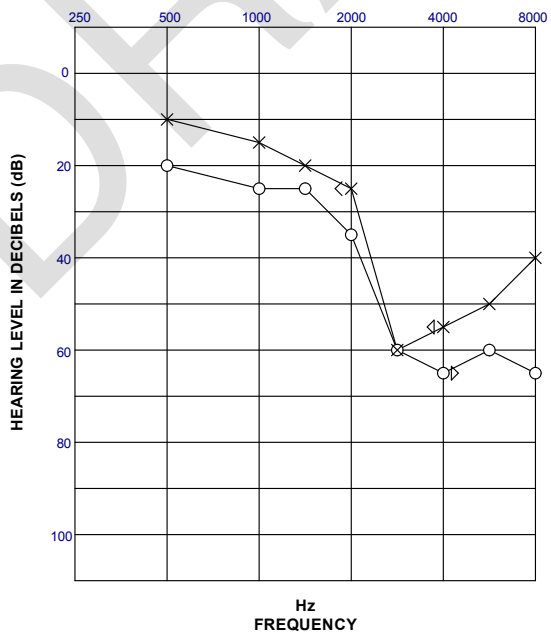
Non-work noise
No noisy hobbies, only noisy domestic activities such as lawn mowing.

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:

- % 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.

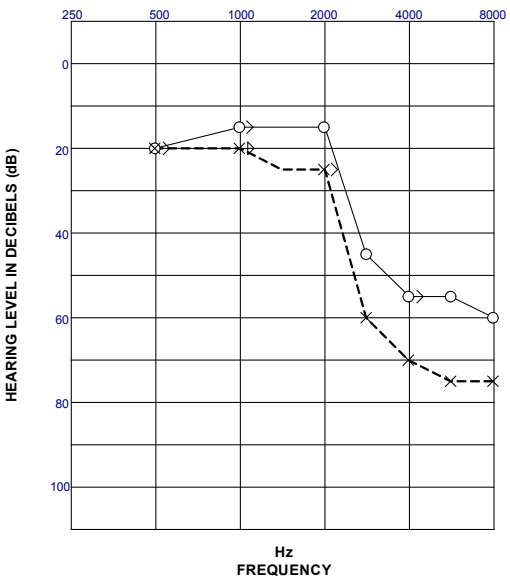
Non-work noise
No noisy hobbies, apart from occasional duck shooting in the 1970s.

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

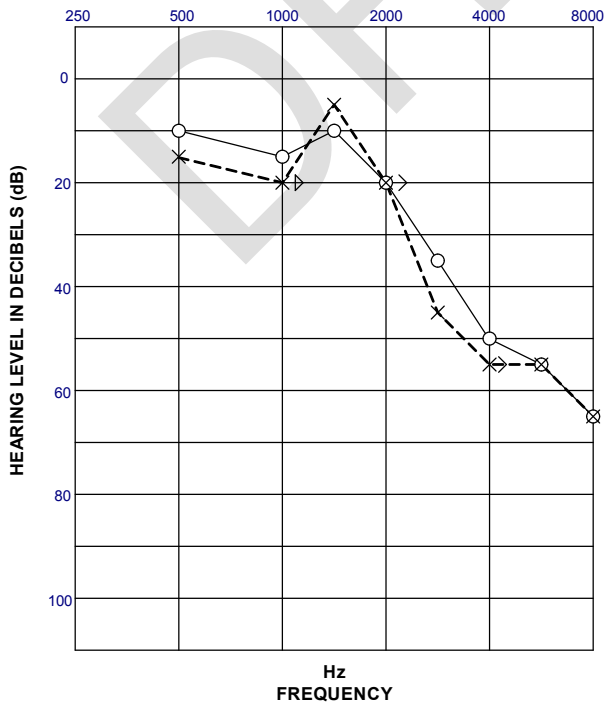
Past history
No history of head injury or ototoxic drugs. No family history of hearing loss. Difficulty hearing in the presence of background noise (but no indication given of how long this had been the case).

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.

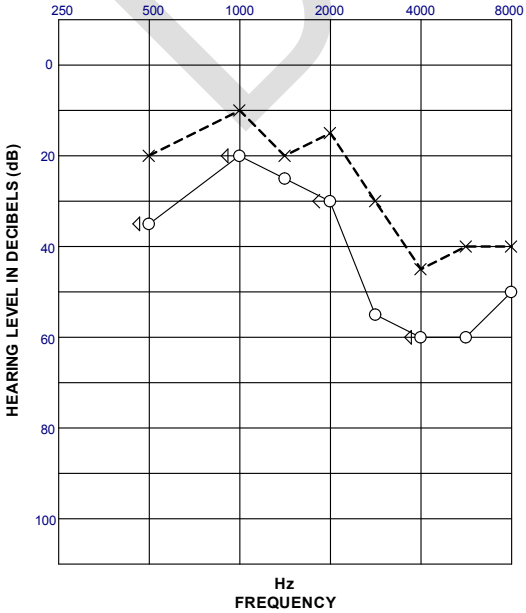
Non-work noise
Carpentry at home, including building two houses for himself in Australia; recreational shooting of deer and goats (2,000 rounds per year using a variety of weapons). Right-handed shooter.

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 claimant 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.

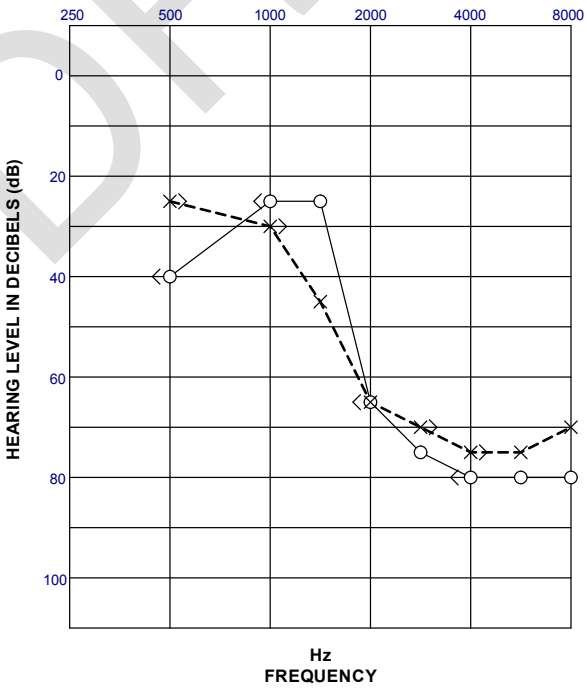
Non-work noise
Mower, power tools, with no ear protection. Occasionally used a .303 rifle in his youth.

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 years.

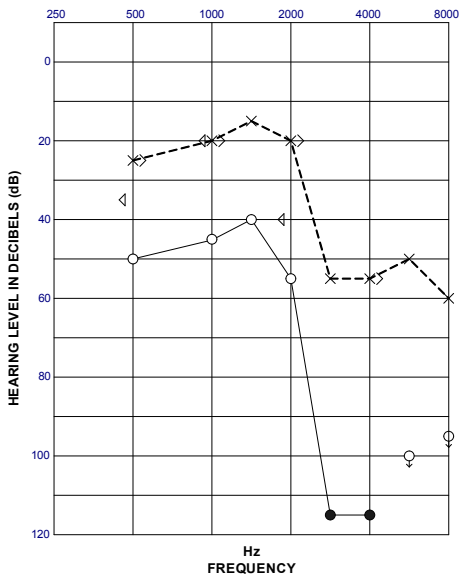
Past history
History of ear infections as a child, with long history of grade 1 bilateral fairly continual tinnitus. No history of head injury.

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 them 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.

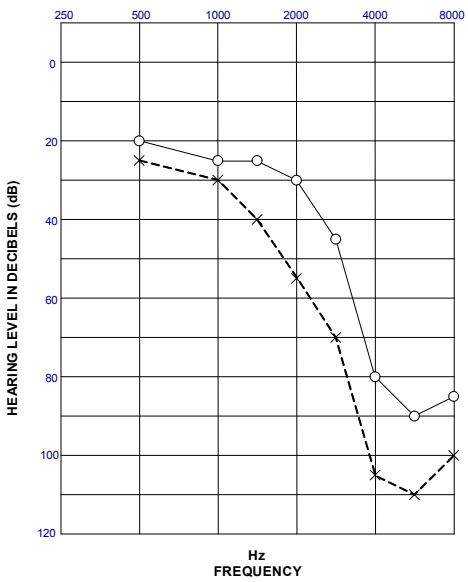
Non-work noise
Shooting, mainly for claybirds – 100-200 shots per year. Right-handed shooter.

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 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.

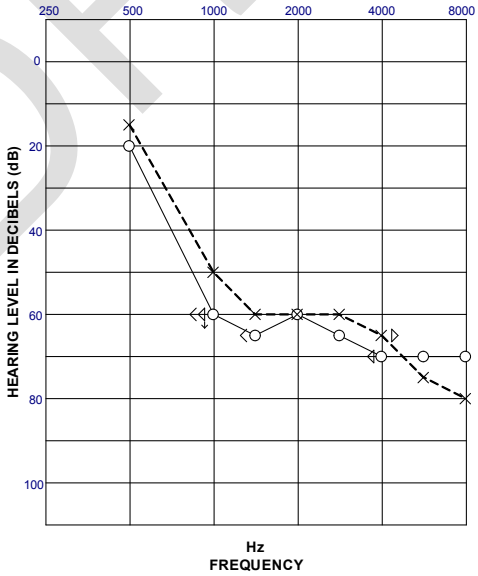
Non-work noise
None of significance.

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
Binaural									48.7

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 dBA – 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.

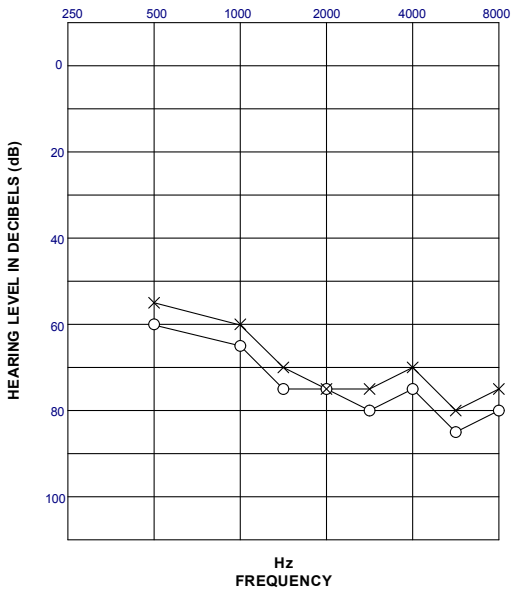
Non-work noise
Nil reported.

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 dBA. 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

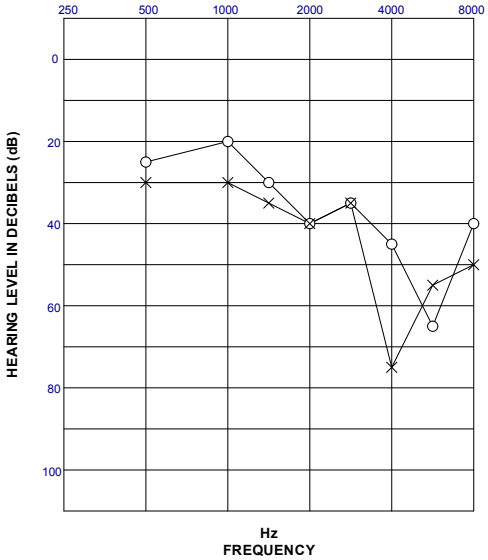
Right	60	65	75	75	80	75	85	80	77.4
Left	55	60	70	75	75	70	80	75	71.5
Binaural									72.4

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 claimant'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.

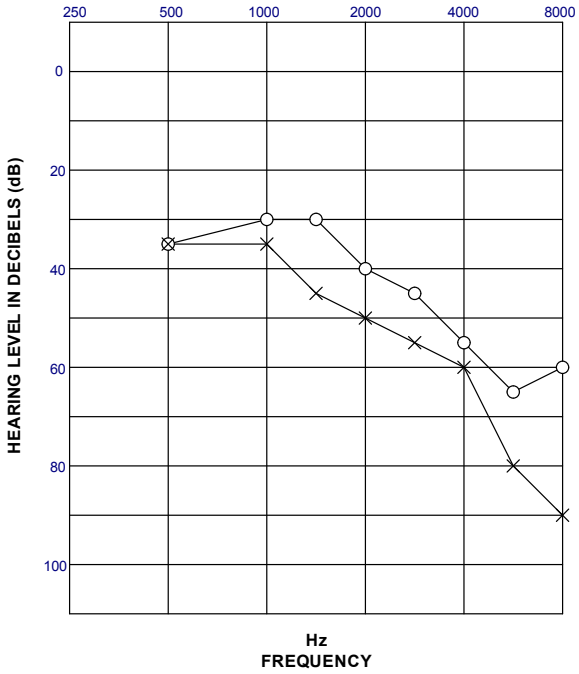
Non-work noise
Nil.

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 claimant 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 dBA and overlockers at L_{eq} 78 dBA. Given that there were about 100 machines operating, the overall noise levels would have been equivalent to 85-90 dBA, consistent with the claimant'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 claimant'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 claimant'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 claimant, 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: ACC 723 Hearing Loss Assessment Specialist Otolaryngologist Report

ACC 723

HEARING LOSS ASSESSMENT

Specialist Otolaryngologist Report

PREVENTION. CARE. RECOVERY

Te Kaporeihana Āwhina Hunga Wha

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:

2. PROVIDER

Provider name:	Provider number:

3. CLIENT

Client name:	
Claim number:	Date of birth:

4.

Date of assessment:	Purchase order number:

PART TWO: REPORT

1. PREVIOUS

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? 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:	Yes	No
Military noise exposure		
Does the client have a history consistent with exposure to noise in the military likely to cause hearing loss? If so, please provide details:	Yes	No
Non-work-related noise exposure		
Does the client have any exposure to non-work-related noise likely to cause hearing loss? If so, please provide details:	Yes	No
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? If so, please provide details (including whether an ACC claim was lodged):	Yes	No
Family history		
Does the client have a family history of hearing loss? If so, please provide details:	Yes	No
Ototoxicity		
Does the client have a history consistent with exposure to drugs that might have caused or contributed to hearing loss?	Yes	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? If so, please provide details:	Yes No

3. CLINICAL

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? If so, please describe:	Yes No

4. HEARING LOSS

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? If not, please explain why: Please specify other tests that you believe are required, and the reasons:	Yes No

5. SUMMARY AND

Summary of hearing loss
On the basis of the audiometric findings, please describe the client's hearing loss:
Apportionment of causes *(refer to Assessment of Occupational Noise-Induced Hearing Loss for ACC)*

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	
Is the client's pattern of hearing loss typical of the effects of noise?	Yes No
If not, and you believe it to be work-related NIHL please explain why:	
Summarise your view of the case, explaining your apportionment of the client's hearing loss between occupational NIHL and other causes:	
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?	
Do you think any other information or expert opinion would be beneficial in further assessment of this case?	Yes No
If so, please provide details:	
Hearing rehabilitation	
Is a trial of hearing aids recommended for this client's hearing loss?	Yes No
If so, is the need for aids Binaural Right only Left only Other	
Please comment on the client's wish for and/or motivation to use rehabilitative devices:	

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.

Appendix B: ACC 724 Claimant history form

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 & Hetu[28]

Level	Definition	Measure	
Impairment			
Body	Loss or abnormality of psychological, physiological or anatomical structure or function	Simple Sensitivity Frequency resolution/ discrimination Temporal resolution Tinnitus Spatial resolution Speech component processing Intensity processing	Complex Speech discrimination in quiet Speech discrimination in noise Music recognition Discrimination of environmental sounds
Disability ***(activity limitation)***			

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

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	Understanding speech Listening to speech Location in time and space Identification Tolerance of noise	Speech in quiet or noise Live voice One-to-one Groups/meetings Theatre/opera In the car Strangers/dialects Religious services Recorded voice Telephone TV/video Radio P/A systems Cinema Signal detection Telephone bell Door bell Music Birdsong Water boiling Localisation Warning signals Footsteps Traffic Identification Music Birdsong Stethoscope Crossing signals Environmental awareness Clock/watch Wind Traffic Noise intolerance
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.	Orientation Physical independence Occupation Economic self-sufficiency Social integration	May require aids for listening; ease of listening dependent on levels of background noise; assistance may be required from others Customary environment may create physical obstacles to independence; difficulty engaging in activities outside the home; may require assistance from others May not be able to continue customary occupation without alterations of activities Economic demands of disability may create economic hardship, depending on economic resources Diminished participation, reduction in secondary contacts 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

Appendix E: Coles, Lutman & Buffin: Guidelines on the diagnosis of noise-induced hearing loss for medicolegal purposes[29]

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

Appendix F: ACOEM Guidelines

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
Average daily noise exposure dBA 8 hours/day 5 days/ week 50 weeks/year	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*
95	6	10	15	20	36	46	44	*6*	*5*
100	11	15	21	26	47	56	52	*12*	*11*

30 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	12	17	29	39	39	*4*	*3*
95	7	10	16	23	38	47	45	*7*	*6*
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
Average daily noise exposure dBA 8 hours/day 5 days/week 50 weeks/ year	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
Average daily noise exposure dBA 8 hours/day 5 days/ week 50 weeks/ year	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								
	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*
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

	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

	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							***PLH***	
		500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted
Average daily noise exposure dBA 8 hours/day 5 days/week 50 weeks/ year	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									
	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									
	5,000	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*