

Noise induced hearing loss (NIHL) assessment for workers' compensation

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Introduction

Background

Workers' compensation for Noise Induced Hearing loss (NIHL) is currently an area of interest for WorkSafe Victoria. Particularly, the focus is on determining whether the current assessment method for measuring NIHL reflects best-practice and provides reliable and consistent outcomes. Further, to what extent non occupational hearing loss such as age related hearing loss, could be discriminated from occupational hearing loss.

In Victoria, guidelines by the National Acoustic Laboratories (NAL) are followed in combination with guidelines from the Australian Society of Otolaryngology Head and Neck Surgery (ASOHNS). The assessment of NIHL is also in accordance with Australian Standards (e.g. sound proof room, calibration). The NAL tables calculate % loss of binaural hearing loss and correct for presbycusis.

The NAL figure is converted to calculate % whole person impairment (WPI) and there is an eligibility threshold of 10% WPI for compensation. For further claims there is no need to meet this threshold again; they will be compensated incrementally.

In other states and territories in Australia most schemes have developed their own guides for the assessment of permanent impairment. Legislation directs use of these guides, which sets out both particular methodologies to follow and which parts of other guides such as the AMA Guides and NAL procedures may be utilized (Flett 2009).

WorkCover NSW introduced their Guides for the Evaluation of Permanent Impairment in 2001; this has since been adopted by WorkCover ACT, adapted by WorkCover WA in 2005 and by WorkCover SA in April 2009. Chapter 9 within these documents relates to hearing, except for WorkCover WA (2007a) where it is chapter 11. WorkCover WA does not utilize their Guides for ONIHL, only other types of hearing impairment (WorkCover WA 2007a); the method of assessment for ONIHL is according to Part 3 of the Workers' Compensation and Injury Management Regulations 1982. A 2007 review (WorkCover WA 2007b) recommended development of a Code of Practice for Noise Induced Hearing Loss.

The reason for the introduction guides of their own was mostly to be current and relevant to the jurisdiction's clinical, community and legislative context. Guides based on the NSW model are more comprehensive than the ASOHNS guides currently utilized by WorkSafe, as they cover methods of assessment for all compensable permanent impairments.

ComCare also developed a Guide to the Assessment of the Degree of Permanent Impairment in accordance with their legislation; Seacare's Guide to the Assessment of the Degree of Permanent Impairment is based on the ComCare document.

The guidelines used by WorkSafe were last revised in 2000; there has been a recent trend of revising or developing guides undertaken by WorkCover NSW (2009), WorkCover SA (2009), WorkCover WA (2007), ComCare (2006) and Seacare (2006). However, whilst there has been action in this area, the method of assessing hearing loss has not significantly changed, remaining as some form of pure tone

audiometry. New Zealand has not updated their User Handbook to AMA 4 since its introduction in 2002, and WorkSafe NT, WorkCover Tasmania and QComp do not have guidelines for the assessment of permanent impairment or noise induced hearing loss (Flett et al. 2009)

Objective:

1. To evaluate the workers' compensation scheme for NIHL used by WorkSafe Victoria and compare their guidelines with other existing international standards, rules or regulations.
2. To evaluate the adjustment calculations for presbycusis by the NAL tables by comparing them with other international or national standards.
3. To evaluate the eligibility thresholds for hearing loss used by WorkSafe Victoria by comparing them with eligibility thresholds used in other countries or states regarding NIHL claims.
4. To evaluate if restrictions on time after noise exposure or restrictions on age on filing claims for NIHL should be recommended to WorkSafe Victoria.

Methodology:

For this part of the project we reviewed the major guidelines and tables related to NIHL and claims: NAL tables, ASOHNs guidelines and AMA guides, relevant ISO-standards and the ACOEM guidelines.

We asked our contacts from foreign national insurance bodies or occupational health departments how they handled NIHL claims and what type of guidelines they used. We send a questionnaire with open questions to these contacts. If these people thought someone else would be more capable to answer the particular questions they could forward our questionnaire on to them.

We searched the literature databases from the Centers for Disease Control and Prevention (www.CDC.gov) such as The National Institute for Occupational Safety and Health (NIOSH), and NIOSHTIC-2 (a searchable bibliographic database of occupational safety and health publications, supported in whole or in part by NIOSH). We looked for further information in the website of the International Labour organisation (ILO) and World Health Organisation (WHO).

We searched for up-to-date literature in PubMed using the following search terms:

- "Hearing Loss/ Noise Induced"[MeSH]
- "Workers' Compensation"[MeSH]
- "Presbycusis" [MeSH]
- "Disability Evaluation [MeSH]

What guidelines can be used for the assessment of noise induced hearing loss?

1. Description of available guidelines and tables to be used for NIHL claims

NAL tables

The NAL tables are based on “Improved Procedure for Determining Percentage Loss of Hearing” NAL Report No. 118, January 1988

This report presents empirical formulae and computer programs which can be used to calculate binaural and monaural percentage loss of hearing (PLH) accurately in hearing threshold level (HTL) steps as small as 0.5 dB or less. The binaural and monaural PLH tables are based on calculations from the ISO 7029 first edition from 1984. The NAL tables for PLH provide calculation tables that take the effect of ageing and gender into account, since hearing deteriorates faster as a result of ageing in men than in women.

When purchasing the NAL tables for PLH determination, you can either use the booklet with the formula and the tables to do the calculations or you can use the computer program that will do the calculations for you. The frequency range of the binaural and monaural PLH tables is 500 to 4000 Hz, but can be extended to 8000 Hz if required in special circumstances.

These tables are currently used by Victoria, Queensland and Tasmania. WorkSafe NSW uses the NAL tables for the allowance of presbycusis. WorkSafe WA only uses these tables for other hearing disabilities (not ONIHL).

ISO 7029 has already published a new edition in 2000. In the foreword of the ISO 7029 (2000) it states that this edition cancels and replaces the previous edition however it presents the same data as the first edition, so does not differ technically from that.

ISO 7029 Acoustics – Statistical distribution of hearing thresholds as a function of age

This International Standard provides descriptive statistics of the hearing threshold for populations of various ages. It specifies the following, for the range of audiometric frequencies from 125 Hz to 8000 Hz and for populations of otologically normal persons of a given age within the age limits of 18 years to 70 years:

- a) the expected median value of hearing thresholds given relative to the median hearing threshold at the age of 18 years;
- b) the expected statistical distribution above and below the median value.

The data are applicable for estimating the amount of hearing loss caused by a specific agent in a population. Such a comparison is valid if the population under study consists of persons who are otologically normal except for the effect of the specific agent. Noise exposure is an example of a specific agent and for this

application selected data from this International Standard are referred to as “Data Base A” in ISO 1999.

There have been some critical comments on the validity of the ISO 7029 thresholds, as the threshold data are mainly based on studies from the 1950s, 1960s and 1970s, and there is a possibility that these data may be inaccurate due to outdated selection criteria and calibration procedures. Furthermore, the current ISO standard does not include subjects beyond 70 years of age, and nor are thresholds in the extended high-frequency range included in the standard. A study by Stenklev et al. 2004 compared the thresholds of a random sample of 232 elderly subjects with a battery of audiological tests, including pure-tone audiometry in the conventional and extended high-frequency range, using the normative distributions from the ISO 7029 for comparison. Sixty otologically normal (ON) subjects were selected for comparative analysis with the unscreened (US) sample, and for description of gender and age group differences. With the use of a mathematical transformation of threshold data, it was found that the ISO 7029 normative α coefficient in females may be set too low compared to their sample in the lower frequencies, leading to an underestimation of hearing thresholds in ON females. In their ON sample, hearing thresholds deteriorated with age in the extended high frequency audiometric range. No gender threshold differences were found, although the prevalence of unmeasurable responses was higher in males at some of these frequencies. The ON screening criteria in ISO 7029 may be unreliable in subjects over 60 years of age, as threshold differences between ON and US subjects were not consistent at any frequency (Stenklev 2004).

ISO 1999 Acoustics- Determination of occupational noise exposure and estimation of noise-induced hearing impairment

This international standard presents, in statistical terms, the relationship between noise exposures and the ‘noise-induced permanent threshold shift’ (NIPTS) in people of various ages. It provides procedures for estimating the hearing impairment due to noise exposure of populations free from auditory impairment other than that due to noise (with allowance for the effects of age) or of unscreened populations whose hearing capability has been measured or estimated.

The ISO 1999 can be applied to calculation of the risk of sustaining hearing handicap due to regular occupational noise exposure or due to any daily repeated noise exposure. The ISO does not stipulate (in contrast to the first edition of ISO 1999) a specific formula for assessment of the risk of handicap, but specifies uniform methods for the prediction of hearing impairment, which can be used for the assessment of handicap according to the formula desired or stipulated in a specific country.

For the assessment of hearing impairment due to noise exposure, formulae are presented to calculate the NIPTS for audiometric frequencies from 0.5 kHz to 6 kHz for 8 hours per day daily A-weighted sound exposure of $364 \text{ Pa}^2 \cdot \text{s}$ to $1,15 \times 10^5 \text{ Pa}^2 \cdot \text{s}$ (equivalent continuous A-weighted sound pressure level for a normal 8 hours working day from 75 dB to 100 dB), and periods of exposure lasting from 0 to 40 years.

It specifically states that the standard is based on statistical data and therefore shall not be used to predict or assess the hearing impairment of hearing handicap of individual persons.

ISO-1999 is a document that summarizes available NIHL data to estimate the risk of hearing loss from specified levels and durations of noise exposure. This document was published in 1990 and has been republished by the American National Standard Institute (ANSI) as ANSI S3.44 (1996). It is based on a synthesis of Robinson's 1968 data from Great Britain and Passchier-Vermeers's (1968, 1974) summary of several European and American field studies by Johnson (1978).

A study by Toppila et al. in 2001 commented on the variation of the ISO 1999 model for NIHL. Based on the results of their study of 706 workers exposed to noise and including data of various confounders such as serum cholesterol, blood pressure, use of analgesics and smoking habits; they suggested that if confounders are not included in a model estimating NIHL a large variation of NIHL can be expected. This may be the case in the ISO-1999 model where age, sex and exposure are only used as parameters (ISO, 1990). Dobie et al. compared the ISO 1999 predictions with the data from the 1968-1972 Occupational Noise and Hearing Survey (ONHS) and also suggested that the differences for the low-frequency thresholds between the two data-sets could be explained by socio-economic confounders or test procedure effects. (Dobie 2007)

NIOSH

NIOSH conducted the Occupational Noise and Hearing Survey (ONHS) between 1968 and 1972. The data from this survey (using 1172 highly screened male workers) was used as the basis for NIOSH criteria for risk estimates of NIHL. NIOSH revised the criteria document in 1998 with an updated risk assessment of these 1172 male workers (Prince et al., 1997). NIOSH later expanded the number of workers in the screened database to include 894 workers with other risk factors for hearing loss. The analysis of the total unscreened ONHS database has been recently published in two journal articles (Prince, 2002; Prince et al., 2003). The analysis of total unscreened industrial workers found that variability in background risk and distribution of various risk factors for hearing loss may explain some of the diversity in excess of NIHL.

This criteria document re-evaluated the recommended exposure limit (REL) for occupational noise exposure established by NIOSH of 85 decibels, A-weighted, as an 8-hr time-weighted average (85 dBA as an 8-hr TWA). Exposures at or above this level are hazardous.

By incorporating the 4 kHz audiometric frequency into the definition of hearing impairment in the risk assessment, NIOSH found an 8% excess risk of developing occupational NIHL during a 40-year lifetime exposure at the 85-dBA REL. NIOSH previously recommended an exchange rate of 5 dB for the calculation of time-weighted average (TWA) exposures to noise. However, NIOSH now recommends a 3-dB exchange rate, which is more firmly supported by scientific evidence. The 5-dB exchange rate is still used by OSHA and MSHA, but the 3-dB exchange rate has been increasingly supported by national and international consensus.

For workers whose noise exposures equal or exceed 85 dBA, NIOSH recommends a hearing loss prevention program (HLPP) that includes exposure assessment, engineering and administrative controls, proper use of hearing protectors, audiometric evaluation, education and motivation, recordkeeping, and program audits and evaluations.

Audiometric evaluation is an important component of an HLPP. To provide early identification of workers with increasing hearing loss, NIOSH has revised the criterion for significant threshold shift to an increase of 15 dB in the hearing threshold level (HTL) at 0.5, 1, 2, 3, 4, or 6 kHz in either ear, as determined by two consecutive tests. To permit timely intervention and prevent further hearing losses in workers who's HTLs have increased because of occupational noise exposure, NIOSH no longer recommends age correction on individual audiograms.

There has been some critical literature about the potential of annual audiometric testing to detect significant hearing threshold shifts due to annual variability (Hetu 1990). Nevertheless, NIOSH recommends regular audiometric evaluation and states that exit audiometry should also be performed (NIOSH 1998).

AMA guides

American Medical Association (AMA)

The AMA's "Guide to the Evaluation of Permanent Impairment" outlines how the US has interpreted the definitions that inform the assessment for compensation, and these definitions have influenced many other countries' interpretation of compensation (AMA, 1995). The AMA defines "impairment" as the loss, loss of use, or derangement of any body part, system or function. Permanent impairment occurs when the impairment has become static after a period of time sufficient to allow optimal tissue repair. The AMA adds that impairment is a condition that interferes with an individual's activities of daily living, which include spoken or written communication and social activities. The AMA defines "disability" as an alteration of an individual's capacity to meet personal, social or occupational demands. Finally, the AMA guidelines also define the effect of an occupational injury or disease as a "handicap" when the disease or injury presents obstacles to accomplishing life's basic activities.

4th Edition AMA guides; used by NT, QLD, TAS and NZ:

They have based their criteria on the American Academy of Otolaryngology-Head and Neck Surgery.

Evaluation of monaural hearing impairment: if the average of the hearing levels at 0.5, 1, 2 and 3kHz is 25dB or less, according to 1989 ANSI standards, no impairment is considered to exist in the ability to hear everyday sounds under everyday listening conditions.

If the average of the hearing levels at 0.5, 1, 2, 3 kHz is over 91.7dB, the impairment for hearing everyday speech is considered to be total, that is, 100%.

First step: Monaural hearing loss and impairment (%) ; A table is used to calculate the % monaural hearing loss for the sum of decibels threshold levels (at 0.5, 1, 2 and 3 kHz); For every decibel that the average hearing level or loss for speech exceeds 25dB, 1.5% of monaural impairment is assigned.

Second step: Evaluation of binaural hearing impairment: is derived from the pure-tone audiogram and is always based on the functioning of both ears.

Formula: binaural hearing impairment % = $[5 \times (\% \text{ hearing impairment better ear})] + (\% \text{ hearing impairment in poorer ear}) \div 6$.

Or binaural hearing impairment is a weighted average of the right and left ear monaural hearing impairment scores, favouring the better ear (5:1). A table is used to compute binaural hearing impairment.

Third step: Converting binaural hearing impairment to impairment of the whole person. Total deafness is equivalent to 35% whole person impairment.

Tinnitus in the presence of unilateral or bilateral hearing loss may impair speech discrimination; therefore, an impairment percentage up to 5% may be added to the impairment for hearing loss.

AMA guides 5th Edition; used by NSW, SA, ACT, Seacare

The difference with the 4th edition is that it particularly states that in the calculation of a hearing impairment rating, no correction for presbycusis should be made because: 1) the method calculates the degree of hearing and assigns a rating, regardless of cause (e.g. age, injury or noise exposure); 2) age correction would result in a reduced binaural impairment score that would thus underestimate the true magnitude of the hearing impairment; 3) estimation of the relative contributions of various causes of binaural hearing impairment is a clinical process (apportionment or allocation) that is separate from the calculation of binaural hearing impairment.

- Hearing levels are determined according to American National Standards Institute (ANSI) S3.6-1996

The WorkCover NSW guides chapter 9 on hearing applies the assessment of hearing loss according to these AMA guides but does have some additions to the guides for their assessment of permanent impairment of hearing. The main points of the WorkCover NSW guides are:

- The degree of impairment is determined according to the WorkCover Guides instead of the AMA guides.

- The hearing threshold level for pure tones is based on an audiometer that is calibrated according to the Australian Standard AS 2586-1983

- The calculation of monaural hearing impairment and binaural hearing impairment and the conversion to whole person impairment are not according to the AMA guides but are based on the NAL report no. 118. In other words, with these calculations they do include a correction for presbycusis.

Calculation of binaural hearing loss is also different from the formula in the AMA guides:

$$\text{BHI} = [4 \times (\% \text{ better ear hearing loss}) + \% \text{ worse ear hearing loss}] : 5$$

The next step is converting the % binaural hearing loss in % whole person impairment according to table 9.1

- The binaural tables RB 500-4000 (NAL publication, pp 11-16) are used and, when appropriate, according to the medical specialist the frequencies can be extended to 8 kHz (Table EM 4000-8000, pp 32-34)

AMA guides 6th edition

Differences with previous editions are:

- Hearing is measured with pure tone signals at 0.25, 0.5, 1, 2, 3, 4, 6, and 8kHz.
- More discussion about new sophisticated tests such as brain stem evoked response audiometry (BERA), otoacoustic emission tests and middle ear impedance tests.
- More discussion about tinnitus; with a scaling of its severity: slight, mild, mild-moderate, moderate, or severe.
- It explicitly states that if the average of the hearing levels at 0.5, 1,2, and 3 kHz is less than 25 dB, no impairment rating is assigned since there is no change in the ability to hear everyday sounds under everyday listening conditions. This 25 dB limit is NOT a compensatory adjustment for presbycusis.

ASOHNS guidelines

The ASOHNS guidelines draft of July 2010 determines the percentage of hearing loss from the NAL report No. 118 and this percentage should then be converted to whole person impairment (WPI) in accordance with the Accident Compensation Act 1985.

The guidelines specifically state that the assessment should be carried out by an approved hearing loss assessor who carries out a comprehensive otological consultation and examination and takes full responsibility for the accuracy of the audiology. The audiological assessment should include air and bone conduction and include the 6 frequencies required for the impairment assessment: 0.5, 1, 1.5, 2, 3, 4 kHz. If desired the extension tables can be used. Additional testing: impedance and speech audiometry and, if there is uncertainty as to the accuracy of the audiogram, CERA and repeat audiogram are indicated.

The ASOHNS guidelines state that the lowest (least hearing loss) reliable thresholds obtained (including CERA) should be used as the basis for compensation.

Regarding occupational NIHL, the guidelines state that the contribution from various employers and non-occupational noise can be estimated from serial audiograms or from the duration of exposure. It is assumed that NIHL occurs on an equally cumulative basis over the total period of noise exposure. Non-occupational exposure can be disregarded unless there is an asymmetry in the pure tone audiometry test.

The ASOHNS guidelines provide further information on special considerations for non-compensable components.

International Labor Organization (ILO)

The ILO framework (ILO, 2004) does not prescribe standards for assessing the injury for the purposes of compensation, since that is left to individual countries to determine. The ILO framework rather refers to three methods to determine the benefits to be paid for permanent or partial disability:

- a. the physical impairment method: where compensation is calculated with reference to the estimated degree of physical and mental impairment resulting from the disability. Rating charts or injury charts attribute percentage rates to a list of disabilities;
- b. the projected loss of earnings method: where a pension is calculated by estimating the extent to which the earnings are likely to be reduced by the disability; and
- c. the loss of earnings method: where a pension is paid according to the estimated actual loss of earnings resulting from the disability.

American College of Occupational and Environmental Medicine (ACOEM)

ACOEM issued a revision of the criteria regarding NIHL in 2003:

- It is always sensorineural, affecting hair cells in the inner ear.
- Since most noise exposures are symmetric, the hearing loss is typically bilateral.
- Typically, the first sign of hearing loss due to noise exposure is a “notching” of the audiogram at 3, 4, or 6 kHz, with recovery at 8kHz. The exact location of the notch depends on multiple factors including the frequency of the damaging noise and the length of the ear canal. Therefore, in early NIHL, the average hearing thresholds at 0.5, 1, and 2 kHz are better than the average at 3, 4, and 6 kHz and the hearing level at 8 kHz is usually better than the deepest part of the “notch.” This “notching” is in contrast to age-related hearing loss, which also produces high frequency hearing loss, but in a down-sloping pattern without recovery at 8 kHz.
- Noise exposure alone usually does not produce a loss greater than 75 decibels (dB) in high frequencies, and 40 dB in lower frequencies. However, individuals with superimposed age-related losses may have hearing threshold levels in excess of these values.

- The rate of hearing loss due to chronic noise exposure is greatest during the first 10 to 15 years of exposure and decreases as the hearing threshold increases. This is in contrast to age-related loss, which accelerates over time.
- Most scientific evidence indicates that previously noise-exposed ears are not more sensitive to future noise exposure and that hearing loss due to noise does not progress (in excess of what would be expected from the addition of age-related threshold shifts) once the exposure to noise is discontinued.
- In obtaining a history of noise exposure, the clinician should keep in mind that the risk of noise-induced hearing loss is considered to increase significantly with chronic exposures above 85 dBA for an 8-hour time-weighted average (TWA). In general, continuous noise exposure over the years is more damaging than interrupted exposure to noise which permits the ear to have a rest period.

However, short exposures to very high levels of noise in occupations such as construction or fire fighting may produce significant hearing loss, and measures to estimate the health effects of such intermittent noise are lacking. When the noise exposure history indicates the use of hearing protective devices, the clinician should also keep in mind that the real world attenuation provided by hearing protectors may vary widely between individuals.

Summary

- NAL tables are used to calculate hearing loss thresholds taking age and gender into account. Their tables are based on the ISO 7029 first Edition data from 1984. The frequency range is 0.5 up to 4 kHz, but can be extended to 8 kHz.
- ISO 7029 has published a second Edition in 2000 that replaces the first Edition. It provides descriptive statistics of hearing thresholds for populations of various ages up to 70 years for the range of frequencies of 0.25 up to 8 kHz.
- ISO 1999 (1990) or the ANSI s3.44 (1996) provide risk estimates of hearing loss due to noise exposure (taking level and duration into account).
- AMA guides 4th, 5th and 6th Edition advise on the assessment of NIHL; they use the ANSI s3.44 tables for their calculations. AMA 5th Edition particularly states that no correction for presbycusis should be made. AMA 6th Edition suggests to use 8 frequencies (up to 8 kHz) for the calculation of NIHL.
- ACOEM criteria on NIHL states that rate of hearing loss due to noise exposure is greatest during the first 10 to 15 years and hearing loss due to noise does not progress after the exposure has been stopped.

2. What guidelines do other countries use; and how is compensation calculated?

Europe

In Europe the emphasis for NIHL management is on prevention and rehabilitation reflecting the importance put on high levels of social security and the effects of efficient first world standards. The legislation requires employers to provide annual screening audiometry as in other countries. However, the referral for compensation is more liberal than for example in developing countries since it occurs if there is a greater than 40 dB loss at 2 KHz or if the sum of the hearing threshold levels at 1, 2, and 3 KHz deteriorates by more than 30 dB. This emphasis on the lower frequencies reflects the high level of consideration of the quality of life of the recipient of the compensation. The prerequisite for a compensation claim is that the worker must have worked in conditions of greater than 85 dBA noise levels for two years or more. In Germany, for example, the emphasis of assessment for an NIHL compensation claim is not only on pure-tones but also on the speech recognition threshold (SRT). The calculation of the disability only uses 1, 2, and 3 kHz, together with calculation tables that are weighted at 1 kHz (Barnes & Shipman, 1998; EU, 2003).

UK:

In the UK occupational deafness is unusual among prescribed diseases in that the threshold for benefit payment is not 14% but 20% disablement. The Industrial Injuries Advisory Council has published a report in 2002 in which they reviewed the prescription of occupational deafness. In this report they recommend to keep the threshold for benefit payment at 20% disablement. The assessment of occupational deafness should be done with PTA over 3 frequencies: 1,2 and 3 kHz with an average hearing threshold (bilateral) of over 50dB (Department for Work and Pensions). A loss of over 110dB is considered 100%

Finland:

The percentage of impairment is calculated following the Finnish instruction tables of classification of impairment in accident insurance. The instructions and criteria applied depend on the year of occurrence. In NIHL the year of occurrence is the year when constant NIHL-type impairment in high tone hearing first time was assessed. The criteria have been changed a bit in years 1976, 1982, 1986 and the last version 1649/2009 came into operation on the 1st January 2010. In practise, at present in most cases the previous 1986 criteria are used, because we do not see any new mild cases, based on the 2010 criteria, in the compensation process yet.

The degree of impairment in hearing loss (and in other diseases, injuries etc. as well) is given (scored) in impairment classes (Haittaluokka), where 1 class = 5%. For example, getting totally deaf means impairment class 10 (=50%). Unfortunately, the instructions for impairment percentage classification (Scoring tables, Haittaluokitus; impairment scoring into classes 1-20) are not officially published in English.

The Netherlands:

The Netherlands uses a registration guideline for NIHL which is only used for registration purposes.

USA:

A survey of workers' compensation practices for hearing loss in American states/territories and Canadian provinces has been conducted and published in a chapter entitled "Workers' Compensation" by Dobie et al. in The Noise Manual, 5th Edition, American Industrial Hygiene Association in 2000. The authors had obtained the data in late 1998 and early 1999 by a written survey of workers' compensation officials in various jurisdictions. Results of the survey showed that the most commonly specified method for calculating hearing impairment is the latest formula recommended by the American Academy of Otolaryngology (AAO), the "AAO-79" method.

Over forty percent of states/territories reported utilizing the AAO-79 formula by specific reference or by virtue of a requirement to follow the most recent American Medical Association workers' compensation guideline (which specifies use of the AAO-79 formula).

Six states reported still utilizing an older AAO method, the "AAO-59" formula, and several states reported having adopted other variations. It is notable that a full third of jurisdictions stated that a specific formula is not required, rather, that impairment ratings are based on "medical evidence".

In 2001 there has been an update of this information about workers' compensation. In 2012 there will be a new edition of the Noise Manual, the 6th Edition. However, a new table of Workers' Compensation will not be published as the information was simply too difficult to collect and keep current. The authors indicated that collecting this information involved contacting each workers' compensation board by phone, as the policies are rarely published anywhere (print or online), and they often received conflicting answers, with no clear indication of which answer truly represented state or provincial policy. The process for determining monetary awards for workers' compensation claims was typically based on applying the impairment rating to a schedule for lump sum payments, or to extended payments based on a percentage of the individual's wages. There is a great deal of variation across states and provinces in the amount of awards provided for occupational hearing loss.

South Africa:

The hearing threshold levels from the better of the two audiograms are used with the weighted actuarially designed Permanent Loss of Hearing (PLH) tables to calculate a PLH for each of the following five frequencies: 0.5, 1, 2, 3, 4 kHz. The tables are weighted to favour the speech frequencies. The sum of the values for each frequency is the PLH. A baseline audiogram has to be carried out for all current employees and has to be carried out according to legislated standards to ensure reliability. All subsequent audiograms are compared to the baseline PLH (de Koker 2004, RMA guidelines).

Deterioration by 10% or more from the baseline PLH is compensable. Permanent disablement is calculated by halving the value of the PLH. A 100% hearing impairment is therefore equal to 50% permanent disability (RMA guidelines). The new regulations allow for apportionment of liability by the employer causing the NIHL while the previous legislation meant that the employer in whose employ the worker was at the time of the diagnosis carried the liability for the worker irrespective of how

long the worker had been in his employ. The apportioning of liability for NIHL requires that employers keep all documentation available and correct to facilitate fair compensation practices (Barnes 2006; RMA guidelines).

Canada:

Workers' compensation in Canada is delegated to provincial/territorial responsibility. For a high level but informative overview of the Canadian systems, please see the Association of Workers' Compensation Boards of Canada's précis: Canadian Workers' Compensation 101 at

<http://www.awcbc.org/en/canadianworkerscompensation101.asp>

Ontario:

For Ontario WSIB purposes, for claims with accident dates on or after January 2, 1990, sensorineural hearing loss is determined using the rating schedule prescribed in section 18(1), of Ontario Regulation 175/98; this rating schedule is the American Medical Association Guides to the Evaluation of Permanent Impairment, 3rd edition (revised). This is directed through Policy 16-01-04 Noise-Induced Hearing Loss, On/After January 2, 1990: <http://www.wsib.on.ca/wsib/wopm.nsf/Public/160104>

For claims before January 2, 1990, the Hearing Loss Permanent Disability Rating Schedule is used. The schedule is contained in Policy 16-01-03 Occupational Noise-Induced Hearing Loss:

<http://www.wsib.on.ca/wsib/wopm.nsf/Public/160103>

Permanent impairment from sensorineural hearing loss is determined using the rating schedule prescribed in section 18(1), O.Reg 175/98. This rating schedule is the American Medical Association Guides to the Evaluation of Permanent Impairment, 3rd edition (revised) (AMA Guides). Those claimants whose hearing loss is sufficient to result in a permanent impairment benefit as recognized by the AMA Guides (at or above 26.25/26.25 dB or 25/32.5 dB in the better/worse ear, respectively) are referred for a Non-Economic Loss (NEL) determination. Average hearing losses are never rounded for permanent impairment calculations using the AMA Guides.

Hong Kong

In Hong Kong, any persons who believe their hearing has been affected in such a way due to their occupation may apply for compensation through the Occupational Deafness Compensation Board (ODCB). To apply for compensation, all applicants must fulfil the occupation and deafness requirements stated in Chapter 469 of the Occupational Deafness (Compensation) Ordinance (Government of Hong Kong, 1995).

The occupational requirements demand that all applicants have continuously worked for a particular period of time in designated noisy occupations within 12 months prior to application. All those who meet the occupational criteria will undergo hearing assessment to determine if the hearing loss requirements are met. Applicants must

have at least a bilateral moderate (40 dB HL) sensorineural hearing loss over 1000, 2000 and 3000 Hz, and the hearing loss must be noise induced in at least one ear, to be eligible for compensation. The present hearing test protocol of the Occupational Deafness Medical Committee uses pure-tone audiometry (PTA) as the gold standard for measuring hearing sensitivity. The present protocol includes optional objective tests such as the acoustic reflex threshold (ART) test and distortion-product otoacoustic emission (DPOAE), which are frequently performed but have no official status to support PTA results. The present hearing test protocol requires the reliability of all hearing test results to be assessed by the Occupational Deafness Medical Committee. The inclusion of an objective screening tool with validated criteria may assist in determining the reliability of individual results. Such a procedure may serve as an indicator of the likelihood of applicants meeting the hearing loss requirements, helping in the determination of full assessment appointment priorities (Chan 2004).

Summary

Information on compensation policies for NIHL from the included foreign countries revealed that there is an enormous variety in how NIHL is compensated. Jurisdictions vary about the frequencies that are used to measure the hearing loss, the low point that is used as a threshold before a claim is accepted or compensation is possible and they vary about the way compensation is calculated.

3. How is older age taken into consideration when assessing for noise induced hearing loss?

Accounting for presbycusis

It is well known that the sensitivity of human hearing usually falls progressively with age and that the impairment of hearing develops more rapidly for sound at high frequencies than at low frequencies. Moreover, the magnitude of this effect varies considerably among individuals (ISO 7029).

What is presbycusis? (source: Gates & Mills 2005)

Presbycusis is the general term for age-related hearing loss. The disorder is characterised by reduced hearing sensitivity and speech understanding in noisy environments, slowed central processing of acoustic information, and impaired localisation of sound sources. As a result, people with the disorder have difficulty, proportional to the degree of hearing impairment, in conversation, music appreciation, orientation to alarms, and participation in social activities. There are three classic types of the disorder—sensory, strial, and neural—that can occur alone or in combination. Each type has implications for treatment. Because of the high prevalence of presbycusis, hearing difficulty is a common social and health problem. Overall, 10% of the population has a hearing loss great enough to impair communication, and this rate increases to 40% in the population older than 65 years (Ries et al. 1994). 80% of hearing loss cases occurs in elderly people (Davies 1990).

Although hearing worsens with age, the severity of the hearing problem at any given age varies greatly.

It is rare to find a person older than 70 years with no hearing impairment or whose hearing sensitivity has not declined from youthful levels. Literature shows that hearing levels are poorer in industrialised societies than in isolated or agrarian societies. Thus, it is conceptually useful to regard presbycusis as a mixture of acquired auditory stresses, trauma, and otological diseases superimposed upon an intrinsic, genetically controlled, ageing process.

Presbycusis first reduces the ability to understand speech and, later, the ability to detect, identify, and localise sounds. The loss of hearing sensitivity begins in the highest frequencies, which has an adverse effect on understanding speech in noisy or reverberant places. Once the loss progresses to the 2–4 kHz range, which is important in understanding the voiceless consonants (t, p, k, f, s, and ch), speech understanding in any situation is affected. The most common complaint in presbycusis is not that the patient cannot hear, but rather that they cannot understand what is being said.

Dobie et al. constructed a model of hearing loss burden in American adults using data from the Census bureau, from the international standard that predicts age-related and NIHL (ISO 1999), from the American Medical Association method of determining hearing impairment, and from sources estimating the distribution of occupational noise exposure in different age and sex groups. They found that occupational noise exposure probably accounts for less than 10% of the burden of adult hearing loss in the United States; the rest is age-related. Most of the occupational noise burden is attributable to unprotected exposures above 95 dBA, and becomes apparent in middle age, when occupational noise exposure has ceased but age related threshold shifts are added to prior noise induced shifts, resulting in clinically significant impairment (Dobie 2008).

For the assessment of claims for NIHL by workers' compensation schemes it is difficult to calculate what part of the hearing loss is due to noise and what part is due to age. It will also depend on the normative data set used. The NAL tables are based on data from ISO 7029 (first edition, 1984) and ISO based their calculations on data-sets from the 1970s. There is a lot of recent literature available which debates the value of these older data-sets and how to take non-occupational noise into consideration (Adera 1997, Robinson 1996).

In the State of Victoria between November 1997 and June 2009 data from WorkSafe have been analysed in the ISCRR Incidence IB report (Radi et al. 2010) of claims lodged regarding NIHL. It was found that the claimants' mean age was 59.6 years age and ranged from 22 to 90 years. Mean age at claim lodgement increased steadily over the period (1997-2010) from 56 years to 61.6 years. Overall, the 56-65 year age group accounted for more than half the number of claims (55.1%) and the 66+ year age group for almost one in four claims (22.6%). These two age groups experienced the highest rise in the number of claims across the period, with a fourfold and tenfold increase respectively. Thorne et al. reported a similar picture for New Zealand. They analysed claims for NIHL using data from the Accident Compensation Corporation (ACC) and found that most claims were lodged by people

in their 50s and beyond, with increasing numbers among those nearing retirement age.

This illustrates that for workers' compensation schemes the debate about what part of the hearing loss is due to older age and what part is due to noise exposure is very relevant.

Current knowledge and logic suggest that hearing loss due to chronic noise exposure, such as occurs in occupational hearing loss does not worsen after the noise exposure stops (ACOEM Report, 2002). If this is true, then the continued post-exposure changes in the hearing of people with NIHL must be the result of other causes, such as aging or disease.

In general, there are three ways to take age related hearing loss into account when assessing noise induced hearing loss:

1. High threshold; a claim will be accepted if the hearing loss exceeds a relatively high threshold of hearing loss. This high threshold ensures that the likely age-related component of hearing loss is exceeded. UK uses such a high threshold of 50dB.
2. Restriction in time; a claim will be accepted if the time between the occurrence of the hearing loss is measured during or within a limited amount of time after the exposure to noise. Most countries that use a limitation in time after noise exposure will also have a certain threshold of hearing loss before a claim is accepted. However, the threshold is lower than 50dB. Hong Kong and Singapore use a limit of 12 months after exposure to noise for a claim to be accepted.
3. Age correction; a claim will be accepted if the hearing loss exceeds a relatively low threshold of hearing loss after an age correction has been applied to the audiometric results. Many Australian states and territories use the method of age correction.

Thresholds

The most commonly used definition of hearing impairment is a weighted average hearing loss at 1,2,3 and 4 kHz greater than 25dB. Such a hearing loss decreases the capacity for being engaged in conversation in meetings or at social activities, creating a significant barrier in establishing or maintaining emotional relationships (Verbeek 2009).

In workers' compensation schemes hearing loss thresholds are used as a minimum level of hearing loss for eligibility for compensation. If a person has a hearing loss beneath this threshold then the claim will not be accepted, although differences can be made between eligibility for financial compensation or eligibility for the provision of hearing aids.

There are differences in the level of thresholds used by the various countries and states, and there are differences how (based on what frequencies) these thresholds are calculated. For example, most American States and Ontario test the hearing at 0.5,1,2,3 kHz; UK does not use 0.5 kHz; and France tests hearing at 0.5,1,2 and 4 kHz.

The thresholds or 'low' fences of decibels also differ between countries and states. For example, the UK uses a relatively high threshold of 50dB and many other countries use 25dB as the threshold. The decision on what threshold should be used, and based on what frequencies is not only based on the scientific literature but is also a policy decision. The literature has showed that the typical audiogram of a worker shows a notch around 4kHz, and hearing is better at lower frequencies and also around 8kHz. For the older person, the typical audiogram will mostly show a loss of hearing also at 4kHz, but no improvement at the higher frequencies. The audiogram shows a bulge downwards. However, the notch at 4 kHz is neither inevitable, nor exclusive to noise. Noise notches can also be seen at 3kHz and 6 kHz.

For the determination of the level of disability due to hearing loss; the average hearing loss over the lower frequencies give a more precise estimation than only using one frequency. A hearing loss between 0.5 kHz and 4 kHz will affect a person's ability to understand speech. It is also generally accepted that any loss at those frequencies of less or equal to 20dB will not have a major effect. That is why most schemes use a low fence of 25dB.

Restriction in time

The literature so far is not clear on the long term effect of noise exposure on hearing disability. As mentioned before it has been suggested that hearing loss is not progressive after a maximum loss is incurred approximately 10 to 15 years after initial exposure (ISO 1999, Sataloff 2001, ACOEM 2002). Most scientific evidence also indicates that previously noise-exposed ears are not more sensitive to future noise exposure and that hearing loss due to noise does not progress (in excess of what would be expected from the addition of age-related threshold shifts) once the exposure to noise is discontinued (Rosenhall 1990)

A recent large longitudinal study with 10 years of follow up of 3753 adults did not find any residual effect on long-term risk of declining hearing sensitivity among people with normal hearing at baseline and among people exposed to occupational noise at baseline (Cruickshanks 2010). Further results of this longitudinal study showed that education, occupation group and marital status, indicators of socioeconomic status, were associated with the 10-yr cumulative incidence of hearing impairment. The results did not show an association between noise-exposure and the 10 yr incidence or progression of hearing impairment. These findings are in line with another study by Lee et al. who also found that noise history had no effect on the rate of threshold changes. This study followed a group of 188 older adults (average age 68 years) for an average period of 6.4 years. The researchers concluded that on average, hearing threshold increased approximately 1 dB per year for subjects age 60 and over. Age, gender, and initial threshold levels could affect the rate of change in thresholds (Lee 2005).

Cruickshanks et al. suggested that either poor health behaviours (such as increased exposure to smoking, higher alcohol consumption, more atherogenic diets, increased obesity etc.) or through the biological effects of increased stress, the link between socioeconomic status and mortality, cardiovascular disease, and other chronic disease may be explained. The researchers implied that the strong association of presbycusis with socioeconomic status could mean that it is, at least in part, a preventable disorder (Cruickshanks 2010).

Toppila et al. also evaluated the effect of noise, age and confounders in NIHL. Information was collected from 706 workers exposed to noise. They also collected information on the following confounders: smoking habits, serum cholesterol, systolic or diastolic blood pressure and use of analgesics. In the subjects the confounders were a significant source of hearing loss in younger and elderly groups of subjects, serum cholesterol level being the most important. In risk analysis the confounders partly masked the effects of noise in the development of hearing loss. For subjects with less than two confounders, occupational noise exposure determined the development of NIHL. As the number of confounders increased, the noise exposure was overruled by these factors in the development of hearing loss. In analysis where the subjects were matched with pairs by age, exposure, blood pressure and serum cholesterol level, the elderly subjects were more susceptible to NIHL than younger subjects. Factors independently, but causally, related to age were important in the development of NIHL among workers exposed to noise levels below 98 dB(A) (Toppila 2001)

Within Australia:

Age-based restrictions

WorkCover WA was the only workers' compensation scheme with restrictions based on age (until 65 years). However, the 2007 review of NIHL (WorkCover 2007b) recommended a move towards restrictions based on retirement rather than age, particularly in light of equality for an ageing workforce; this may be addressed in the Act review of 2009.

Retirement-based restrictions

Three schemes have restrictions based on retirement, as directed by legislation.

In the Tasmanian scheme, a worker can make a claim for industrial deafness while still employed, or within six months of terminating employment, according to the Workers' Rehabilitation and Compensation Act 1988, S32(2).

In Queensland, an industrial deafness claim must be lodged while a worker is employed or within 12 months of retirement, according to the Workers' Compensation and Rehabilitation 2003 Act, S125 (2).

Workers may not claim for ONIHL incurred after retirement in Western Australia; for workers who retire before they turn 65, only a further claim may be made, for additional hearing loss suffered since a previous lump sum payment, according to the Workers' Compensation and Injury Management Act 1981 S24A(3). This claim must be lodged within 12 months of retirement. Where a worker retires near 65 and

a claim is lodged within the 12 month window, a correction will be made to attempt to ensure no loss after the age of 65 is compensated. No claim may be lodged after this retirement claim, nor on retirement before 65 for workers who have not previously lodged a hearing loss claim (WorkCover 2007b).

The Victorian scheme places no restrictions on when a hearing loss claim can be lodged. They use a threshold of 10% (loss in WPI, based on 10% NAL hearing loss) before a loss of hearing is compensated. In other territories of Australia different thresholds (between 2.5% and 10% loss in WPI) are used.

Thresholds

Eligibility for hearing loss claims varies across jurisdictions, in both magnitude and method of assessment. As discussed, nine Australian schemes base assessment on WPI. Of these, ComCare, WorkCover NSW and WorkCover ACT state their threshold in terms of binaural hearing loss: 5% for ComCare and 6% for WorkCover ACT and WorkCover NSW. This converts to 2.5% WPI (ComCare 2005) and 3% WPI (WorkCover NSW 2009) respectively. Five percent WPI is a common threshold (WorkSafe NT, WorkCover SA, WorkCover Tasmania). At 10% WPI, Victoria's is among the highest, on a par with Seacare and ACC. WorkCover WA set the threshold at 10% loss of hearing for ONIHL, and Q-Comp 5% total hearing loss.

How do other countries or states take age into consideration when assessing for noise induced hearing loss?

Europe:

In the *UK*, age off-sets are not made in the assessment, for administrative simplicity. Instead, a rather high threshold is applied as well as restriction on age since retirements. Awards become payable at 20% disablement: at 50dB averaged over 1, 2 and 3kHz. Studies so far have indicated that the prevalence of hearing impairment is not greatly associated with noise exposure, sex or occupational group, but predominantly with age. (Department for Work and Pension Social Security Administration Act 1992/ Occupational Deafness)

In *Finland*, the distinction between NIHL and presbycusis is necessary during diagnostic process to determine aetiology, but if the hearing loss is defined to be mostly due to occupational noise (>50 % causative proportion), then the proportion of age-related individual or population based average of presbycusis will not be taken off from the total impairment. In a few cases the presbycusis or some other non-occupational cause is so essential in a moderate or severe hearing loss, that the worker is given two hearing loss -diagnoses, e.g. presbycusis or genetic cochlear degeneration partially, and NIHL partially, and these two aetiologies explain the total loss of function. In these cases, the insurance company is naturally responsible for the occupational proportion only.

In the primary aetiology diagnostises, the distinction between NIHL and presbycusis (and other aetiologies) is based on exposure history, otologic history and examination, and especially on the development of hearing loss in audiograms during noisy work years. Leisure noise is evaluated too, but it is only seldom that it

substantially exceeds work noise and therefore excludes the diagnosis of occupational impairment.

France uses a threshold of 35dB on the best ear, which is the mean of the measured deficits in the frequencies equal to 0.5, 1, 2 and 4 kHz. If the worker has again a noisy job, any aggravation will not be taken into account.

In the *Netherlands* hearing loss is measured at 1, 2, and 4 kHz by insurance companies. When on average 30dB loss is measured at these frequencies it is considered as a social handicap (Dobie 2001, NCvB 2009 report) because of the loss in speech hearing. Insurance companies will pay for hearing aids when the average hearing loss for the best ear is more than 35dB and a hearing aid will improve speech hearing by 20%. Hearing loss will be compensated by a separate governmental body involved in workers' benefits and compensations, when the worker is still at work and needs a hearing aid to do his/her work (www.UWV.nl). Compensation will again only concern hearing aids. In the Netherlands the cause of the hearing loss does not make a difference in the compensation.

Asia:

Singapore: For workers who are 50 years old and above, a correction of 0.5% is made for each year above 50 years in the calculation for permanent incapacity.

Hong Kong: Compensation in respect of occupational deafness is payable to successful applicants in a lump sum payment. The amount, which depends on the applicant's age, his/her monthly earnings and percentage of permanent incapacity, is calculated in the following way:

Age Amount of Compensation

Under 40: 96 months' earnings x percentage of permanent incapacity

40 to under 56: 72 months' earnings x percentage of permanent incapacity

56 or above: 48 months' earnings x percentage of permanent incapacity

Taiwan: NIHL is based on the PTA diagram – the typical patterns of NIHL, for example 4-6 kHz dip, and at least dB loss, but not infrequently presbycusis is mixed with the health effect of noise exposure. In that case, the distinction would partly lie on evidence of exposure to decide its work-relatedness.

USA (based on the information from 2001)

Waiting Period

Seventy percent of jurisdictions indicated that no waiting period is necessary for filing a compensation claim. For those jurisdictions that do impose a waiting period, reported time frames ranged from three days to six months.

Duration and Level of Exposure

Many U.S. states include a provision that excludes a claim when the occupational noise exposure is below a specified level, such as 90 dBA TWA. Most Canadian provinces specified minimum exposures of 85 to 90 dBA. In addition, a number of jurisdictions require that the noise exposure duration exceeds a minimum number of days, months or years (particularly in Canada) in order for a claim to be considered. These requirements underscore the importance of accurate and complete noise exposure assessment records as part of the HCP.

Statute of Limitations

The statute of limitations for filing claims varies from jurisdiction to jurisdiction, and was reported to be as short as 30 days to as long as 5 years. In some states, the date of injury is “the last date exposed” to noise, while in others it is the date the employee became aware of the hearing loss or its work-relatedness. Approximately half of Canadian provinces reported no statute of limitations.

Age Adjustments

Over 40 states and provinces indicated that some type of deduction in impairment/award may be made for presbycusis, or hearing loss related to aging. In other jurisdictions, use of a “low fence” of 25 to 30 dB HL is usually considered to account for the effects of aging on hearing.

For example in Washington State (based on personal communication 2010), the Washington State Supreme Court has decided that presbycusis should not be segregated out from NIHL by applying any type of formula. The current method recommended by AMA/AAO is as follows:

1. The average hearing threshold level at 0.5, 1, 2, and 3 kHz should be calculated for each ear.
2. Multiplying should calculate the percentage of impairment for each ear (the monaural loss) by 1.5 times the amount by which the above average exceeds 25 dB (low fence). Hearing impairment is 100% for 92 dB average hearing threshold level.
3. The hearing disability (binaural assessment) is calculated by multiplying the smaller percentage (better ear) by 5, adding it to the larger percentage (poorer ear), and dividing the total by 6.

Ontario:

Workers with occupational NIHL that is sufficient to cause a hearing impairment may be entitled to benefits. Entitlement to health care and rehabilitation benefits begins with a hearing loss of 22.5 dB in each ear when the hearing loss in the 4 speech frequencies (0.5, 1, 2, and 3 kHz) are averaged.

The following is persuasive evidence of work-relatedness in claims for sensorineural hearing loss:

- Continuous exposure to 90 dB(A) of noise for 8 hours per day, for a minimum of 5 years, or the equivalent, and
- A pattern of hearing loss consistent with noise-induced sensorineural hearing loss.

A presbycusis (aging) factor of 0.5 dB is deducted from the measured hearing loss (averaged over the 500, 1000, 2000, and 3000 Hz frequencies) for every year the worker is over the age of 60 at the time of the audiogram. The hearing loss that remains after the presbycusis adjustment is then used to determine entitlement to benefits. Entitlement to health care and rehabilitation benefits is available when the adjusted hearing loss is at least 22.5 dB in each ear.

As for retirement, workers are not restricted in making an initial claim, however, in terms of requesting entitlement for further hearing loss, the policy states “workers with an accepted claim for NIHL who return to noise exposure with the same accident employer are entitled to a NEL redetermination for the additional hearing loss”. The policy also states “when workers with an accepted NIHL claim return to occupational noise exposure with a new accident employer, a new claim file is established to determine entitlement for the additional hearing loss”. This is consistent with the requirement of both noise exposure and hearing loss to establish a claim. In order to extend entitlement, further hearing deterioration needs to be underpinned by further noise exposure that is work-related.

Summary

- Most Victorian claims regarding NIHL come from workers who are over 50 years of age. Evidence so far suggests that the effect of noise on hearing is higher during the first 10 to 15 years of exposure. When the exposure stops no more hearing loss due to noise is expected. There is no valid way to diagnose what part of the hearing loss is due to older age and what part of the hearing loss is due to noise exposure. Workers' compensation schemes have mainly used three basic ways to deal with older age and NIHL (see Table):

1. Thresholds: high hearing loss thresholds are used before a claim is accepted.
2. Age or time restriction: a claim can only be lodged within a limited time after retirement or only during the worker's working life.
3. Age-correction: a certain amount of decibels are extracted from the average hearing loss over various frequencies.

Overall summary

- NAL tables are used to calculate hearing loss thresholds taking age and gender into account. Their tables are based on the ISO 7029 first Edition data from 1984. The frequency range is 0.5 up to 4 kHz, but can be extended to 8 kHz.

- ISO 7029 has published a second Edition in 2000 that replaces the first Edition. It provides descriptive statistics of hearing thresholds for populations of various ages up to 70 years for the range of frequencies of 0.25 up to 8 kHz.

- AMA guides 4th, 5th and 6th Edition advise on the assessment of NIHL; they use the ANSI s3.44 tables for their calculations. AMA 5th Edition particularly states that

no correction for presbycusis should be made. AMA 6th Edition suggests to use 8 frequencies (up to 8 kHz) for the calculation of NIHL.

- ISO 1999 (1990) or the ANSI s3.44 (1996) provide risk estimates of hearing loss due to noise exposure (taking level and duration into account).

Information on compensation policies for NIHL from the included foreign countries revealed that there is an enormous variety in how NIHL is compensated. Jurisdictions differ about the frequencies that are used to measure the hearing loss, they differ about the low point that is used as threshold before a claim is accepted or compensation is possible, and they differ about the way compensation is calculated.

Most claims regarding NIHL come from workers who are over 50 years of age. Evidence so far suggests that the effect of noise on hearing is biggest during the first 10 to 15 years of exposure. When the exposure stops no more hearing loss due to noise is expected. Therefore, it seems reasonable to limit the amount of time between last exposure and lodgement of claim for NIHL, provided that workers are aware of this time limitation.

There is no apparent way to diagnose what part of hearing loss is due to older age and what part is due to noise exposure. Workers' compensation schemes have mainly three basic ways to deal with older age and NIHL (see Table).

In the majority of workers' compensation schemes within Australia thresholds before a claim is accepted are not very high compared with some overseas countries. Victoria, NZ, Seacare and WA have the highest thresholds: 10% WPI which is similar to a binaural HL between 18 and 20 %. Also, for the majority of schemes there is no restriction on time after retirement (or noise exposure) for a claim to be accepted (7 out of 11).

The majority of schemes do apply an extraction of the hearing loss for the presbycusis based on the NAL tables.

Conclusions:

- There are several general guidelines used by the included countries and territories. The majority however, uses the AMA guides. The included European countries most likely have their own national guideline or criteria for how to deal with NIHL.

- The vast majority of countries uses one of the following three options to take older age into account for calculating the hearing loss due to noise exposure: use of high thresholds, time restriction for lodging claims and age-correction in the calculation of the % hearing loss.

- Most Australian territories use the NAL tables for the calculation of % hearing loss with correction for age and gender. These NAL tables are based on an older version of the ISO 7029 standard.

Recommendations:

- This review provides a rationale to limit the time between last noise exposure and/or last employment and lodging a claim for NIHL, provided there is sufficient awareness of this limitation among the Victorian workforce.

- As the majority of other compensation schemes within Australia use the NAL tables for the correction of presbycusis, it is recommended that WorkSafe considers introducing this method. This would require discussion with the National Acoustics Laboratories to identify to what extent their tables are still up to date as they have based their calculations on the first edition of the ISO 7029.

Alternatively, it is an option to use the AMA guides (preferably the latest Edition) in line with the majority of other Australian schemes, who base their calculations on the ISO 1999 (1990) or ANSI standards.

Table on NIHL and the way age is taken into account for workers' compensation schemes and what guidelines are used

Country / State	Method**	Threshold	Restriction in time or age after noise exposure	Extracting age component from hearing loss	Guidelines
USA in general	2,3	> 25 dB HL average at 0.5, 1,2,3 kHz	Varies per jurisdiction between 30 days and 5 years.	Over 40 states indicated that some type of deduction in impairment may be made for presbycusis. Other jurisdictions use a 'low fence' of 25-30dB HL which is considered to account for the effect of presbycusis	AAO-79/AMA guides by 40% of USA States AAOO-59 guides by 6 USA States medical evidence: 33% of USA States
Washington State	2	> 25 dB HL average at 0.5, 1,2,3 kHz	Within 2 years of last injurious exposure.	No	AAO-79/AMA guides
France	2	> 35 dB HL average at 0.5,1,2,4 kHz	Within 1 year of last injurious exposure	No	Comité Regional de Reconnaissance des Maladies Professionnelles, CRRMP (occupational diseases recognition regional committee)
Taiwan	1	>70 dB HL average of 0.5,1,2 kHz	No	No	Guideline published by IOSH (Institute of Occupational Safety and Health) for the assessment. The disability table by the labor insurance regulation for the degree of disability.
UK	1,2	> 50 dB HL average of 1,2,3 kHz *	Within 5 years of last injurious exposure	No	Social Security (General Benefit) Regulations 1982 which medical assessors use as a framework for deciding % disablement awards for both scheduled and non-scheduled assessments.
Germany	2	> 20% whole-person permanent impairment	Only during working life is claiming possible	?	Königsteiner Merkblatt
Hong Kong	3	> 40 dB HL average of 1,2,3 kHz.	no	Lump sum payment depending on the age, income and amount of hearing disablement	According to the Occupational Deafness (Compensation) Ordinance www.odcb.org.hk
Singapore	1,3	> 50 dB HL average of 1,2,3 kHz	no	Correction is made for presbycusis for workers above 50 years of age.	The Guide to the Assessment of Traumatic Injuries and Occupational Diseases for Workmen's Compensation.
Ontario/ Canada	3	>22.5 dB HL average of 0.5,1,2,3 kHz	no	For every year the worker is over the age of 60 yrs 0.5 dB is deducted from the average HL over the four frequencies.	AAO-79/AMA guides
Finland	other	requires at least NIHL in impairment class 2 (i.e. 10%)	no	the distinction between NIHL and presbycusis is necessary during etiology diagnostic process; but if HL is defined mostly due to occupational noise, then no proportion of age related HL will be taken off	The Ordinance of Occupational Diseases (1347/88)
In Australia					

Vic	3	10% threshold WPI (for claims after 1997)	No	based on the NAL tables	ASOHNs guidelines
NSW	3	> 6% dB HL average of 0.5, 1, 1.5, 2, 3, 4 kHz (6, 8 kHz optional)	No	based on the NAL tables	AMA 5 th Edition guides → Guides for the Evaluation of Permanent Impairment (2001)
ACT	2,3	> 6% dB HL average of 0.5, 1, 1.5, 2, 3, 4 kHz (6, 8 kHz optional)	No	based on the NAL tables/ adjust for loss attributed to age; 0.5 decibels for each complete year of a worker's age over the age of 55 years for a male and 65 years for a female	AMA 5 th Edition guides/ based on the NSW guides (2001)/ Workers' Compensation Act 1951, S63
NT	?	5% WPI threshold	No	No	AMA 4 th Edition guides
QLD	2	>5% dB HL average of 0.5, 1, 1.5, 2, 3, 4 kHz	yes, within 12 months of retirement	based on the NAL tables	AMA 4 th Edition guides/ 2003 Workers' Compensation and Rehabilitation Act, S125(4)
TAS	2,3	>5% dB HL average of 0.5, 1, 1.5, 2, 3, 4 kHz	yes, within 6 months of retirement	based on the NAL tables	AMA 4 th Edition guides/ Workers' Rehabilitation and Compensation Act 1988
NZ	other	10 % threshold WPI (based on 8 frequencies)	No	No	AMA 4 th Edition guides/ User handbook to AMA 4
SA	2,3	5% dB HL average of 0.5, 1, 1.5, 2, 3, 4 kHz	? within 2 years	based on the NAL tables	AMA 5 th Edition guides/ based on the NSW guides (2009)
Seacare	3	10% WPI threshold	No	yes, according to Comcare	AMA 5 th Edition guides → Guide to the Assessment of the Degree of Permanent Impairment 2 nd Edition
WA	2,3	> 10% dB HL from baseline assessment	yes, if retire before 65 years, within 12 months	based on the NAL tables	For NIHL Workers' Compensation and Injury Management Regulation 1982; reviewed in 2007/2009
Comcare	3	> 5% dB HL average of 0.5, 1, 1.5, 2, 3, 4 kHz (6, 8 kHz optional)	No	Hearing defects are assess in accordance with the current procedures from Australian Hearing (Ch. 7.1) Correction is made for presbycusis	AMA 5 th Edition guides → Guide to the Assessment of the Degree of Permanent Impairment, 2 nd Edition

* These frequencies are predominantly involved in speech discrimination and produce reliable, repeatable audiometric results. (Social Security Administration Act 1992)

** Method 1 = high threshold, Method 2 = restriction in time or age, Method 3 = age-correction

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Information from national bodies in foreign countries:

- for Singapore:

http://www.mom.gov.sg/publish/etc/medialib/mom_library/Workplace_Safety/workmen_injury_compensation.Par.64474.File.dat/GATIOD%20Fifth%20Edition.pdf

- for Washington state: answers to questionnaire

- for UK: answers to questionnaire and from Department for Work and Pensions Social Security Administration Act 1992 (issue Nov 2002)

- for France: answers to questionnaire

- for Taiwan: answers to questionnaire

- for Netherlands: answers to questionnaire

- for Germany: answers to questionnaire

- for Ontario: answers to questionnaire and Policy 16-01-04 Noise-Induced Hearing Loss, On/After January 2, 1990: <http://www.wsib.on.ca/wsib/wopm.nsf/Public/160104>

or

Policy 16-01-03 Occupational Noise-Induced Hearing Loss (applies to accidents before January 2, 1990): <http://www.wsib.on.ca/wsib/wopm.nsf/Public/160103>

- for Finland: answers to questionnaire

- for British Columbia: answers to questionnaire