

NOISE INDUCED HEARING LOSS AND TINNITUS

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Accompanying documents to this report

Noise Induced Hearing Loss and Tinnitus
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Introduction

Tinnitus is the perception of sound in the absence of external acoustic stimulation. The perceived sounds can vary greatly including crackling, whistling, buzzing or humming, and may be continuous or intermittent. The term tinnitus is derived from the Latin word 'tinnire', which means to ring or tinkle (Hobson 2007).

Tinnitus sufferers hear a noise that apparently arises from the ears, or within the head. In many cases tinnitus is associated with some degree of hearing loss, particularly in those individuals who have been exposed to excessive noise. While the perception of noise is, for the patient, very real, there is usually no corresponding external sound and for this reason it can be considered a 'hallucination', a 'phantom', or a false perception. Objective tinnitus (that is, perceivable by both patient and observer) can be secondary to conditions such as temporomandibular joint dysfunction (conditions affecting the jaw joint), vascular tumours and malformations (blood vessel enlargement) and contractions of the palatal muscles (muscles of the soft palate).

Prevalence

The prevalence of tinnitus is much higher than the number of patients who seek treatment, thus indicating that many individuals who experience tinnitus do not find it to be a significant or debilitating problem. Tinnitus becomes a problem when it is perceived as threat, appears continually intrusive, or when patients have difficulty coping with tinnitus as a stress factor (Henry 2005).

Tinnitus is a common condition and up to 18% of the population in industrialised countries are affected mildly by tinnitus. Up to 2% of the population are thought to suffer to a debilitating degree with anxiety, depression or altered sleep patterns reported (Hobson 2007). A minority of sufferers will have an identifiable structural abnormality such as acoustic neuroma, Ménière's disease or otosclerosis which may be amenable to current surgical treatment. Epidemiological data reports are few. The data described by the Institute of Hearing Research (UK) in 1981 refer to a prevalence of tinnitus in 15.5% to 18.6% of 6804 participants who completed a questionnaire in four cities (MRC 1981). This is consistent with the data collected by the American Tinnitus Association (ATA) which points to a prevalence of tinnitus in 50 million, or about 19%, of Americans (ATA 2001). Data exist for Japan, Europe and Australia, and estimates suggest that tinnitus affects a

similar percentage of those populations. One to two per cent of the population experience debilitating tinnitus, severely limiting the quality of life of affected individuals (Seidman 1998). In a survey in Germany 1.5 million adults experience tinnitus as being 'considerably annoying' (Pilgramm 1999). Age-specific tinnitus prevalence data in adults show a trend of increasingly greater prevalence of tinnitus for higher age. Studies have also showed a plateau in tinnitus prevalence in either the 60-69 years or 70-79 years age ranges, with a subsequent decline in prevalence for higher age groups (Henry 2005).

Aetiology

Almost any form of disorder involving the inner ear or the auditory nervous system may produce tinnitus. Around 90% of people with hearing loss experience some degree of tinnitus. Tinnitus can occur as an isolated symptom without a recognisable cause. It can also occur in association with a middle or inner ear disorder, such as sensorineural hearing loss, otosclerosis, intoxication with certain drugs, sudden deafness or Ménière's disease. Environmental factors can also cause tinnitus. The most relevant and frequently reported are: explosions or gunfire, exposure to occupational noise, exposure to recreational and amplified music and more recently as a result of airbag inflation. Iatrogenic factors causing tinnitus include drug-induced ototoxicity caused by, for example, the use of some antimicrobial and chemotherapeutic agents, quinine, aspirin overdose and platinum cytotoxics (Lockwood 2002).

Causes of subjective Tinnitus:

Otologic: NIHL, presbycusis, otosclerosis, otitis, impacted cerumen, sudden deafness, Meniere's disease, and other causes of hearing loss

Neurologic: head injury, whiplash, multiple sclerosis, vestibular schwannoma, or other cerebellar-pontine-angle tumours

Infectious: otitis media and sequelae of Lyme disease, meningitis, syphilis, and other infectious or inflammatory processes that affect hearing

Drug-related: common side effect of many drugs, such as salicylates, nonsteroidal anti-inflammatory drugs, aminoglycoside antibiotics, loop diuretics, loop diuretics, and chemotherapy agents (e.g. platins and vincristine)

Other: Temporomandibular-joint dysfunction and other dental disorders

Causes of objective Tinnitus:

Pulsatile: Carotid stenosis, arteriovenous malformations, other vascular anomalies, vascular tumours (e.g. of the glomus jugulare), valvular heart disease (usually aortic stenosis), states of high cardiac output (anaemia and drug-induced high output), and other conditions causing turbulent blood flow

Muscular or anatomical: Palatal myoclonus, spasm of stapedius or tensor tympani muscle, patulous Eustachian tube

Spontaneous: Spontaneous otoacoustic emissions

Pathophysiology

The pathophysiology of tinnitus is not yet fully understood. There are several theories of the pathophysiology of tinnitus (Martina-Devesa 2007):

One theory suggests that tinnitus is caused by excessive or abnormal spontaneous activity in the auditory system and in related cerebral areas. Lockwood proposed that the perception of tinnitus arises not in the ears but in the brain. Experimentally delivered audiometric pure tones presented to subjects with tinnitus activate changes in cerebral blood flow in more portions of the brains of tinnitus patients than in controls when assessed with Positron Emission Tomography (PET). This suggests that 'abnormal connections' in the central auditory system may play a role in tinnitus perception.

In the 'neurophysiological model for tinnitus' it is proposed that tinnitus results from the abnormal processing of a signal generated in the auditory system. This abnormal processing occurs before the signal is perceived centrally. This may result in 'feedback', whereby the annoyance created by the tinnitus causes the individual to focus increasingly on the noise, which in turn exacerbates the annoyance and so a 'vicious cycle' develops. In this model tinnitus could therefore result from continuous firing of cochlear fibres to the brain, from hyperactivity of cochlear hair cells or from permanent damage to these cells being translated neuronally into a 'phantom' sound-like signal that the brain 'believes' it is hearing. For this reason tinnitus may be compared to chronic pain of central origin - a sort of 'auditory pain'. In all these models of tinnitus generation and perception, the relationship between the symptom of tinnitus and the activity of the prefrontal cortex and limbic system has been emphasised. The limbic system mediates emotions. It can be of great importance in understanding why the sensation of tinnitus is in many cases so distressing

for the patient. It also suggests why, when symptoms are severe, tinnitus can be associated with major depression, anxiety and other psychosomatic and/or psychological disturbances leading to a progressive deterioration of quality of life.

There are many more theories about the pathophysiology of tinnitus.

Diagnosis

Patients with tinnitus should undergo a comprehensive neurologic assessment in order to determine whether there is any serious or underlying cause of the tinnitus. A clear description of the sound the patient hears is important: Is the sound constant or episodic, unilateral or bilateral? Was the onset sudden or gradual? How long has it been present? What are the pitch and loudness of the sound? Is there associated hearing loss, vertigo or pain? Are there any other conditions that could be associated with tinnitus such as head injury, otitis, drug use or vascular anomalies? What else affects tinnitus; background noise, alcohol, stress, or sleeplessness? How does tinnitus affect daily life and the ability to function? (Lockwood 2002)

After a thorough history, a physical examination with complete head and neck assessment, including examination of the cranial nerves, should be performed. Other neurological testing of the cerebellar and other functions should be performed, as indicated. In addition to a routine audiogram, testing commonly includes assessment of hearing at frequencies not tested routinely. Other audiometry tests should include measures of acoustic impedance (tympanometry, acoustic-reflex thresholds), speech audiometry, and tests for maskability. Unilateral high-frequency hearing loss combined with poor speech discrimination suggests the possibility of a tumour, usually a vestibular schwannoma or meningioma (Lockwood 2002). Patients with these findings must undergo additional audiometry tests such as brainstem evoked-response audiogram (BERA); balance tests such as electronystagmogram (ENG) and computerized dynamic posturography (CDP); otoacoustic emission (OAE) testing; and imaging studies. Blood tests for diabetes, hypoglycemia, hyperlipoproteinemia, Lyme disease, syphilitic labyrinthitis, thyroid dysfunction, collagen vascular disease, autoimmune inner-ear disease, and other conditions are usually recommended (Sataloff 2008).

It is important to evaluate the effect of tinnitus on daily life. Surprisingly, the perceived severity of tinnitus is unrelated to measurements of its loudness or pitch (Lockwood 2002). The effect of tinnitus is greatest in patients who report physical immobility, sleeplessness,

and pain and among those who are depressed or irritable, who are socially isolated, or who have psychiatric symptoms.

For the evaluation of the severity of subjective tinnitus many instruments have been published, the majority being questionnaires. These questionnaires provide an index score to quantify the impact of tinnitus on the quality of life of the patient. Examples of these types of questionnaires are the (Tinnitus Severity Index) and the Tinnitus Handicap Inventory (THI). Although, both questionnaires have been tested for their internal consistency and generalisability for their use in the clinical field, their use for medico-legal purposes have been questioned (McCombe 2001).

Treatment

At present no specific therapy for tinnitus is acknowledged to be satisfactory in all patients. However, there are many options for treatment. The majority of patients who complain of tinnitus and who also have a significant hearing impairment will benefit from a hearing aid. Not only will this help their hearing disability, but also the severity of their tinnitus may be reduced.

Counselling is also an important component of treatment for tinnitus. Psychological treatments such as cognitive behavioural treatment, hypnosis, relaxation treatment and biofeedback have all been used and may help to lower the distress caused by tinnitus. In recent years increasing attention has been given to the method known as tinnitus retraining therapy (TRT). This is a therapeutic process that uses a combination of low level, broad-band noise and counselling to achieve 'habituation'. The aim of the treatment is to redirect the brain's 'attentional focus' away from the tinnitus signal.

Many medications have also been proposed to relieve tinnitus:

- tricyclic antidepressants improved tinnitus related disability in people with or without depression and chronic tinnitus and this medication has been evaluated in a Cochrane review (Baldo 2006).
- lidocaine is a local anaesthetic that with intravenous (IV) administration has been shown to abolish tinnitus in about 50% of the cases. However, IV administration of lidocaine is not a practical treatment (Henry 2007)
- benzodiazepines and anti-epileptic drugs, but most studies have not shown a conclusive benefit of these medications (Henry 2007).

Other interventions include Ginkgo biloba, acupuncture, electromagnetic stimulation and low power laser. Alternatively, masking devices can be used. Masking devices work on the principle of distraction; that if a level of noise, usually 'white noise', is introduced it can reduce the contrast between the tinnitus signal and background activity in the auditory system, with a decrease in the patient's perception of their tinnitus.

Tinnitus and Workers compensation in Australia (Flett 2009)

Tinnitus is compensable in most jurisdictions, as an addition of up to five percent to the impairment for hearing loss, usually before conversion to WPI. WorkSafe Victoria does not compensate for tinnitus and WorkCover WA doesn't compensate for tinnitus with ONIHL.

In Western Australia, tinnitus is compensable only for other types of hearing impairment, in accordance with their guides for permanent impairment (WorkCover WA 2007a). Tinnitus was not compensable in New South Wales until the introduction of the WorkCover NSW (2001) Guides for the Evaluation of Permanent Impairment (the WorkCover NSW Guides). This may also be the case for WorkCover ACT, and is true of WorkCover WA for other types of hearing impairment that are subject to the guides. The WorkCover NSW Guides were developed through consultation with working parties – for the hearing chapter, this consisted of a panel of ENTs. Strong feedback from one particular ENT who advocated for tinnitus to be compensable was the key factor in inclusion of tinnitus in the WorkCover NSW Guides (personal communication). The statements from the 2001 WorkCover NSW Guides regarding tinnitus have been replicated in the WorkCover SA (2009) and WorkCover WA (2007) guides for permanent impairment.

With legislation that came into effect 1 April 2009 WorkCover SA moved away from their previous approach of compensating for tinnitus separately. Previously when a hearing loss claim was lodged, the process was to determine whether a tinnitus claim was also eligible (personal communication).

ComCare and Seacare have allowed 5% for severe tinnitus since introduction of the relevant compensation legislation (1988 and 1992 respectively). ACC and Q-Comp add a value up to five to WPI for hearing loss in accordance with AMA-4. In New Zealand, this is only since the introduction of the User Handbook to AMA-4 (personal communication). While contacts from WorkCover Tasmania and WorkSafe NT commented there were no

special provisions or loading for tinnitus in the relevant Acts, assessment is according to AMA-4 and so may allow for tinnitus as above.

In 2007 WorkCover WA undertook a comprehensive review of NIHL. No recommendation was made to introduce compensation for tinnitus; the author considered there was insufficient evidence to form a position, with no real agreement regarding determination of whether tinnitus is work-related or physiological, and tinnitus remaining a contentious issue (personal communication).

To further evaluate whether or not tinnitus should be included in the workers' compensation system of WorkSafe Victoria the relationship between tinnitus and exposure to noise at work, and NIHL are of interest. In particular the following questions need to be answered:

- 1.1 What is the association between tinnitus and noise at the workplace?
- 1.2 What is the association between tinnitus and NIHL?
- 2.1 What is the effect of tinnitus on quality of life and the workers' ability to keep working?
- 2.2 What do guidelines say about compensation for tinnitus?
- 2.3 How do foreign countries handle medico legal claims regarding tinnitus?

Methods

For our literature search we searched in the various databases or websites from February 2010 until April 2010. We have not done a formal systematic review but tried to achieve a comprehensive overview of the existing published and unpublished literature on this topic. We combined the information from scientific medical databases with several informative websites on tinnitus, and information from our contacts in foreign countries.

1. Search in PubMed, limit English language and published in last 10 years

1) "Tinnitus"[MeSH] AND "Hearing Loss/Noise Induced"[MeSH] : 224 hits

2) "Tinnitus"[MeSH] AND "Workers' Compensation"[Mesh]: 13 hits

3) "Tinnitus"[MeSH] AND (Etiology/Narrow[filter]): 117 hits

4) "Tinnitus"[MeSH] AND "Quality of Life" [MeSH]: 100 hits

2. Search in Cochrane Collaboration Library on Tinnitus; 4 reviews dealing with different types of therapy for Tinnitus → background information mostly

3. Search in Toxnet → nothing relevant

4. Search in Niosh → 154 hits → mostly all regarding prevention of NIHL and tinnitus; two important documents:

"Preventing occupational hearing loss/A practical guide" DHHS (NIOSH) Publication No. 96-110; 1996

"Occupational noise exposure/ revised criteria 1998" DHHS (NIOSH) Publication No. 98-126; 1998

5. Search in CISDOC/ LABORDOC via ILO → no relevant publications

6. Search in Web of Science: search tinnitus AND workers → 32 hits with overlap from the search result in PubMed

7. www.tinnitus.asn.au → no further information used

8. www.hse.gov.uk : A review of the current state of knowledge on tinnitus in relation to noise exposure and hearing loss; Prepared by the Health and Safety Laboratory for the

Health and Safety Executive 2010. This was a very useful report that helped answer the first two questions on this topic.

There was a lot of overlap with the retrieved articles from PubMed and the HSE report, so we decided to combine the information. Further, if an interesting article on the topic was retrieved, references were checked to see if there would be more relevant information.

We also asked our contacts from national insurance bodies or occupational health research departments in ten foreign states or countries about the official views of including tinnitus for workers compensation in their countries. We received information from eight states or countries on this topic.

1.1 What is the association between tinnitus and noise at the workplace?

Relevant journal articles

In 2010 the Health and Safety Laboratory published a comprehensive report on tinnitus and the relation to noise exposure at the workplace (HSL 2010). They had searched twelve major databases on scientific medical information between 1951 and 201 and found twenty three papers that reported information on the prevalence of tinnitus in populations exposed to noise at work. The majority of those studies were also retrieved by our searches as described in the method section.

These 23 studies in the HSL document all had a cross-sectional design with only four studies including information on tinnitus in non-exposed populations. The prevalence of tinnitus in the non-exposed groups varied between 2 and 14.4%. In the same studies, the prevalence of tinnitus in the noise exposed group was significantly higher ranging between 12 and 70.4% (HSL 2010).

In the other 19 publications the prevalence of tinnitus ranged between 5.9 and 87.5% for workers exposed to noise, but in these studies no information was provided for workers not exposed to noise. Two of those studies were conducted in drop-forge workers and the noise exposure in this industry is of an impulsive nature, rather than a continuous nature which may suggest that impulsive noise leads to more tinnitus. Three very large studies reported a relatively low prevalence of tinnitus in workers exposed to noise ranging between 5.9 to 6.7% (HSL 2010).

The authors of the HSL report commented that factors such as the definition of tinnitus used (especially whether transient effects after exposure to noise are included), and the prevalence of NIHL may have had an effect upon the reported prevalence of tinnitus.

The report identified 9 papers that reported about the relationship between severity of noise exposure and tinnitus. Four studies measured actual noise exposure and the prevalence of tinnitus, and demonstrated different relationships. Three of these studies did not investigate whether the occurrence of NIHL was also an important factor.

Another cross sectional study (not mentioned in the HSE report) by Rubak et al. with 752 workers employed at 91 workplaces reported that tinnitus was not associated with the present noise level, the duration of noise exposure, or the cumulative noise exposure if

participants had normal hearing. Such trends were demonstrated if participants had a hearing handicap (Rubak 2008).

Two studies (Palmer 2002, Sindhusake 2004) assessed severity of noise exposure by asking how difficult it was to speak or be heard in the work environment. One cross-sectional study with 21201 workers in the UK reported that significant hearing difficulties and tinnitus are quite common in men from the older working age range (Palmer 2002) They found for workers in a noisy job for 1-5 years a prevalence ratio of 1.8 and this increased to 2.6 for workers in a noisy job for more than 10 years. A cross-sectional study executed in Australia (Sindhusake 2004) reported that for individuals whose exposure to noise was tolerable the relative risk was 1.39 and for those who were unable to hear speech at their workplace, the relative risk was 1.53. The population in this study had an average age of 69.8 years.

The report by the HSL also described three studies who had investigated the relationship between tinnitus and duration of noise exposure. All three studies suggested that there is a relation between duration of noise exposure and risk of tinnitus. Another Brazilian study, not included in the HSL report, measured the noise exposure and tinnitus prevalence in 372 workers. Twenty two percent of these workers complained about tinnitus. The authors found significant correlations between the frequency of tinnitus episodes and the noise levels to which workers were exposed (Steinmetz 2009).

A longitudinal and cross-sectional gerontological and geriatric population study of 70-year-olds in Gothenburg by Rosenhall et al. reported that the incidence of tinnitus increased in old age, but not at the same high rate as presbycusis. According to this study tinnitus in old age is more related to hearing loss than to ageing. There are no simple correlations between exposure to noise during the active years and tinnitus in old age (Rosenhall 2003).

1.2 What is the association between tinnitus and NIHL?

Relevant journal articles

We found two studies comparing the prevalence of tinnitus in populations with or without NIHL and these studies demonstrated an increase in prevalence of tinnitus in those with hearing loss (Griest 1998, Palmer 2002). One study, which was a 15-year longitudinal study involving noise-exposed workers, found that the prevalence of tinnitus in workers with 10dB hearing thresholds was 16% compared to 42% in workers with 15dB hearing thresholds ($p=0.005$) (Griest 1998). In the study by Palmer et al., who used self-reported hearing difficulty as their measure of hearing loss, showed that the age standardized prevalence of persistent tinnitus was 16.1% in those who reported severe difficulties in hearing, as compared to 5% in those with slight or no difficulties in hearing (Palmer 2002).

A cross-sectional study by Dias et al. investigated a dose-response relationship between hearing loss and tinnitus for 284 workers exposed to occupational noise. For the definition of hearing loss they used particular criteria to decide on the type and severity of the hearing loss which were described as occupational criteria by Merluzzi. Results showed that 60% of the ears had hearing loss and 46% had tinnitus. They found a significant association that corresponded with the greater the hearing loss the greater the discomfort introduced by tinnitus (Dias 2008).

The HSL report of 2010 had also found seven other studies who had investigated the relationship between the severity of hearing loss and the prevalence of tinnitus (HSL 2010). A problem with these studies is that the definition of tinnitus was not always clear. Five of these seven cross-sectional studies reported a positive correlation between the prevalence of tinnitus and the severity of the hearing loss. Two studies, also with a cross-sectional design did not find this relation. The prevalence of NIHL and tinnitus in all these studies were not similar, suggesting differences in susceptibility for NIHL or for tinnitus. Another interesting finding is that two studies analyzed which factors were most important to determine hearing loss, and both found that tinnitus was an important risk factor for the development of hearing loss.

One particular study with a longitudinal design of 15 years with 91 noise exposed workers reported that 90% of workers with both tinnitus and hearing loss had the tinnitus complaints on average 5.8 years before the hearing loss took place (Griest 1998).

A Finnish study on NIHL and tinnitus reported that only 4% of the NIHL cases initially reported tinnitus, but that their investigation showed that 88.7% actually had tinnitus (Mrena 2007). The explanation of the authors was that in Finland, tinnitus alone does not warrant compensation, contrary to the practice in some other countries. The present system in Finland focuses only on speech –frequency hearing loss, resulting in possible under-acknowledgement and under-reporting of tinnitus. Tinnitus may actually be more troublesome than hearing loss; focus on tinnitus is thus warranted. However, reliable tinnitus handicap assessment may be difficult and demanding, especially in cases involving possible compensation and financial benefit.

According to 1995 statistics, Finland reported the highest incidence rate of NIHL cases (6.32 per 10000) compared to other countries in Europe. However, in these statistics 15db threshold was used for hearing impairment in Finland, Austria and Denmark, instead of the more commonly used 20db threshold. Probably the more mild cases were reported as well in these countries. For example in Ireland a threshold of 50db hearing loss is used. According to the authors tinnitus should also be regarded as a condition with rehabilitation potential such as tinnitus retraining therapy.

Regarding hearing thresholds and tinnitus different results were found:

A small study by König et al. measured the differences in audiograms between patients with NIHL without tinnitus (n=30) and patients with NIHL with tone-like tinnitus (n=24) and patients with NIHL and noise-like tinnitus (n=17). Analysis showed that tinnitus patients had less overall hearing loss than patients without tinnitus. The audiograms of those patients with tinnitus had a higher maximum steepness compared to those without tinnitus. The area under the curve of the audiogram was used as overall hearing loss. The researchers found that the overall hearing loss in those with tinnitus was significantly lower ($p=0.0006$). The authors concluded that the occurrence of tinnitus is promoted by a steep audiogram slope (König 2002).

A small study by Muluk et al. found a positive but non significant association between hearing thresholds and tinnitus for 31 workers in a steel factory exposed to noise (Muluk 2008).

The study by Steinmetz et al. who did find a relation between noise exposure and tinnitus, reported no significant correlation between audiometry test results and tinnitus periodicity or audiometry and test results and tinnitus severity. Seventy one percent of subjects with

tinnitus had normal hearing. The authors explained their findings and the difference with the literature with that their study population was younger (on average 29 years) and the exposure to noise was for a shorter period of time (6.8 years on average). (Steinmetz 2009).

Another study by Searchfield related the audiometric results of 79 tinnitus patients to two self-report questionnaires: the Tinnitus Handicap Questionnaire (THQ) and the Tinnitus Severity Index (TSI). The TSI did not show any correlation with hearing thresholds; however the THQ was correlated to low frequency thresholds. They also found that audiometry from the right ear is more correlated with tinnitus handicap than from the left ear (Searchfield 2007).

In a Dutch cross-sectional study among 241 musicians 121 (51%) complained of having episodes of tinnitus. Some participants reported very loud and continuous tinnitus and in these cases the tinnitus could cause a serious handicap. At the moment of the audiogram there were 42 (17%) participants who had tinnitus at that particular moment of the test. Those with a tinnitus episode had significantly worse average pure-tone thresholds than the ones without tinnitus at the moment of the test ($p = 0.03$). This was especially the case for the higher frequencies. Not surprisingly, the average age of the participants with tinnitus at the moment of the test was also higher ($p < 0.000$) (Jansen 2009).

The HSE report (2010) found another seven studies reporting on the association between hearing thresholds and tinnitus. All those studies found a significant relation meaning that the higher the threshold the more chance the worker also has tinnitus complaints.

Information on prevalence of tinnitus in association with NIHL from websites of foreign countries

<http://www.medicine.manchester.ac.uk/oeh/research/thor/schemes/ossa/>

Occupational and Environmental Health Manchester: Occupational surveillance scheme for audiological physicians (OSSA):

The OSSA reporting scheme collected information on work-related audiological disorders from 1997 to 2006, and consisted of 13 Consultants in Audiological Medicine from across the UK. The reporting physicians included 7 'core' reported who report on a monthly basis, and 6 'sample' physicians who reported for one randomly allocated month each year.

The most frequently reported disease category within OSSA is sensorineural hearing loss; classed as mild, moderate or severe. Other categories include Tinnitus (mild or severe), Balance problems and Tympanic disorders.

Conclusion: hearing loss and tinnitus are often co-diagnosed, with 46.7% of cases of sensorineural hearing loss reported to OSSA also reported as having tinnitus.

According to OSSA reports, the industry's most frequently associated with sensorineural hearing loss include a variety of manufacturing industries, the construction trade and public administration & defence of which 88.9% relate to the armed forces.

Summary:

Prevalence of tinnitus in workers exposed to noise at work varies considerably, with the majority of retrieved studies not comparing their results with workers not exposed to noise. A dose-response relation between the severity of noise (exposure level and duration) and the frequency of tinnitus episodes was reported in 10 studies. Five studies measured actual noise exposure and the prevalence of tinnitus, and demonstrated different relationships. A problem is that three of these five studies did not investigate the co-occurrence of NIHL.

The majority of studies support the association between tinnitus and NIHL. The prevalence of tinnitus is higher for those with NIHL and hearing thresholds in those with tinnitus are higher. All but one study had a cross sectional design and therefore it remains unclear whether hearing loss and tinnitus occur as independent effects of noise exposure, or whether one is causally related to the other. The longitudinal study suggests there may be a causal relationship, but more research is necessary.

2.1 Does tinnitus reduce workers' ability to keep working or quality of life?

Relevant journal articles

With the search in PubMed on this topic we found an enormous amount of studies describing the potential impact of tinnitus on quality of life. However, not all people with tinnitus have severe distress symptoms and therefore the more recent studies have focused on the reason why some people have severe tinnitus complaints and others do not. It has been suggested that maybe people with vulnerability for anxiety or depression, or people with a certain personality may have a higher risk of suffering from tinnitus (Bartels 2010). Further, the combination of tinnitus and continuous exposure to noise at work can also further strengthen distress symptoms. We particularly looked at 6 recent journal articles.

In a study by Andersson, the long-term outcome of tinnitus patients was studied in terms of changes in occupational status from admission to follow-up for an average duration of 5 years. A consecutive series of 189 tinnitus patients seen between the years 1988 and 1995 were sent a postal questionnaire booklet; 146 provided usable responses (a 77% response rate). Results showed a significant change in occupational status, which was explained partly by retirement because of old age. Few were unemployed at follow-up, and relatively few were on sick leave. These data suggest that tinnitus patients may be less of a demand for the sickness benefit system in Sweden, but it may reflect also that tinnitus is not accepted as a cause for sick absenteeism (Andersson 2000).

A small prospective study by Muluk et al. with 31 males working in a steel factory; half of them had tinnitus. Aim of the study was to investigate quality of life for these workers. The researchers found that older age, industrial noise exposure over a long period, higher noise exposure during work, and hearing loss secondary to occupational noise caused workers to experience higher TLLs (tinnitus loudness levels). Important factors that affect workers' quality of life are maximum exposed noise levels, daily and total noise exposure time, and exposure to continuous noise. The researchers concluded that occupational noise-induced tinnitus mainly causes emotional disability rather than physical disability. Emotionally impaired quality of life results may be due to tinnitus-related psychological problems (Muluk 2008).

Another study explored the association whether a subject's hearing loss contributes to the handicap caused by tinnitus. A group of 96 adults were evaluated with Pure Tone

Audiometry and a questionnaire that included the Tinnitus Handicap Inventory (THI). In 58% of the subjects, the side of the unilateral or worse tinnitus corresponded with the ear with poorer hearing thresholds. A subset of the THI, the Two Question Mean (TQM) that was related to questions with regard to communication, correlated significantly with the hearing thresholds in the better hearing ear ($p < 0.01$). There was also a significant correlation between the THI and TQM scores ($p < 0.01$). These results suggested that in tinnitus subjects with impaired hearing, the underlying hearing loss may be a significant factor in the perceived distress (Ratnayake 2009).

The study by Steinmetz et al. showed that most participants (41%) stated that they had weekly episodes of tinnitus and they were mostly bothered at night. Participants reported that tinnitus did interfere with their quality of life and this concerned mostly their social daily tasks, while reading, sleeping and when performing tasks that require concentration, hearing acuity and attention. Tinnitus also increased tiredness and was accentuated with stress. The authors suggested that tinnitus should be included in hearing loss prevention programs as it is a highly prevalent condition that may adversely impact various spheres of human life (Steinmetz 2009).

The Blue Mountain Hearing study by Gopinath et al. followed 1214 older participants for five years. They analyzed the prevalence of hearing loss and associated tinnitus. They evaluated the effect of tinnitus on quality of life using two health scales: SF-36 and a depression scale (CES-D-10). In their cohort, SF-36 scores tended to be lower for those who first reported tinnitus at the follow-up (incident tinnitus) compared with those who reported tinnitus at both baseline and follow-up studies (prevalent tinnitus), although mean scores failed to reach statistical significance. They also found that participants with tinnitus at baseline and those who developed incident tinnitus had up to a 2-fold increased risk of having depressive symptoms. Their data suggested that the duration of tinnitus did not appear to be an important factor in relation to its impact on mental well-being; hence, the mere presence of tinnitus whether recent or prolonged, may cause significant psychological distress in older adults. The authors concluded that it is likely that symptomatic psychological distress in the form of depressive symptoms among tinnitus patients may have contributed to the substantial impairment of health-related QOL observed in older adults. Further, depression may facilitate the progression of tinnitus from a relatively tolerable sensation into a severely annoying or even disabling one (Gopinath 2010).

2.2 Guidelines on compensation for tinnitus

The AMA guides 4th, 5th and 6th Edition all propose that tinnitus should be compensated up to 5% when it accompanies hearing loss and clearly interferes with quality of life.

The 6th Edition has the most extensive description:

“It has been speculated that tinnitus may be the result of a continuous stream of discharges along the auditory nerve to the brain caused by abnormal irritation in the sensorineural pathway. Although no sound is reaching the ear, the spontaneous nerve discharge may cause the patient to experience a false sensation of sound. This theory sounds logical, but there is no scientific proof of its validity. The major problem with evaluating tinnitus is that it is primarily a subjective phenomenon. Consequently, it is frequently difficult to verify even the presence of tinnitus, let alone its consequences. Nonetheless, if the tinnitus interferes with Activities of Daily Living (ADLs), including sleep, reading (and other tasks requiring concentration), enjoyment of quiet recreation, and emotional well being; up to 5% may be added to a measurable binaural hearing impairment. There is currently no way to scientifically evaluate tinnitus, although validated instruments such as the Tinnitus Handicap Inventory (THI) have been used. Consequently, because physicians are often required to rate tinnitus, a variety of individually devised systems has been created using reasonable data sources. However, these are not standardized or generally accepted by any official medical organization, such as the American Academy of Otolaryngology-Head and Neck Surgery or the American Medical Association. As an example, tinnitus may be scaled as slight, mild, mild-moderate, moderate or severe. Verification of the presence of tinnitus through techniques matching loudness and pitch is fraught with pitfalls, and not recommended.”

The guidelines from the Australian Society of Otolaryngology, Head and Neck Surgery (ASOHNs) (Victorian section) have based their recommendation on the AMA guides 4th Edition, and state that up to 5% may be added to the impairment caused by hearing loss.

They suggest the following criteria need to be met:

- A- A link can be established between the tinnitus and the compensable hearing loss
- B- The tinnitus is continuous and sufficiently troublesome for the claimant to have sought treatment from a medical practitioner

C- The percentage deemed appropriate for the tinnitus can then be added to the percentage loss of hearing before conversion to the Whole Person Impairment.

They further state that the percentage allocated depends on the degree to which the tinnitus affects the capacity to listen to speech and affects general wellbeing. Using the AMA Guides grades of intensity; minimal 0%, slight 1%, moderate 2-3%, and marked 4-5%.

As the AMA guides allow only for the effect of tinnitus on speech discrimination the only types of treatment appropriate in the context of these guidelines for tinnitus are hearing aids where appropriate for the hearing loss and general advice on tinnitus management.

2.3 How do other countries handle medico legal claims regarding tinnitus?

Relevant journal articles:

We found one narrative review about the evaluation of tinnitus for compensation for the situation in the USA (Tyler 2002). The review mainly deals with the considerations when evaluating a tinnitus patient for compensation. The author states that first thing is to determine that the patient actually has tinnitus by asking particular questions. Next, it is important to determine the severity. For this, the tinnitus impairment questionnaire can be used. Third, the most probable cause for tinnitus needs to be determined.

Another journal article we found was by Belgian authors. They developed a system to try to reach maximum medico legal objectivity. This system exists of a four-level decision structure. An aggregate of multiple –choice responses (affirmative, neutral, negative) to elementary questions leads to a decision of the next level, which in turn determines –together with the other decisions at the same level- the conclusion at a still higher level. A positive outcome on all four level-3 questions is required for recognition of noise-induced hearing loss-related tinnitus as an occupational disorder and for financial compensation (Dejonckere 2005).

In the narrative review by Henry et al. we found that workers' compensation programs in 29 of the 50 United States compensate workers for tinnitus (Dobie, 2001). In 13 of these states, tinnitus is compensated only if hearing impairment is also present. In most states, statutes of limitations (which define the period within which legal action can be taken) range from 1 to 5 years. In some states, the statute of limitations is only 30–200 days. Vernon (1996) and Tyler (2003) have noted that tinnitus litigation involves establishing the presence, etiology, and severity of tinnitus. Vernon also noted the necessity of establishing the permanency of tinnitus, and Dobie (2001) stressed the importance of historic documentation. Because tinnitus is by nature subjective, there is no objective measure to prove its existence or to verify the reported severity. Tinnitus assessment, like pain assessment, depends on subjective scaling, self-report, and medical history. Thus, any litigation involving tinnitus must rely on the reliability of tinnitus psychoacoustic measures, consistency of verbal responses and medical records, and sufficient duration of the tinnitus condition to establish permanency (minimum of 2 years duration was proposed by Vernon; Henry, 2004a)

Information via websites and answers to our questionnaire:

The UK does recognize severe tinnitus for potential additional hearing loss:

“Discretion exists to allow the decision maker, on the basis of clinical judgement of a medical adviser, to increase the disablement assessment to reflect the effects of tinnitus. The severity of tinnitus is assessed by a detailed history from the claimant using non-directive questions. Details of the approximate date of onset, how often tinnitus is present, whether it interferes with sleep or concentration, whether the patient has sought medical advice etc, all assist in determining the severity of the tinnitus in the individual. Severe tinnitus, (ie in a case where it has been present for 2 or more years; is constant and interferes with concentration and the ability to carry out normal social and occupational activities; causes disturbance of sleep pattern; and there is evidence that treatment has been sought (e.g. maskers, and/ or medication to control sleep etc)), is likely to increase the amount of disablement resulting from noise-induced deafness by the order of 5% or 6%”. (Department for Work and Pensions 2002)

From an overview of 2006 in a book by Sataloff & Sataloff on occupational hearing loss we found that 17 states in the USA do compensate for additional hearing loss if the claimant also suffers from tinnitus, 18 states do not compensate for tinnitus and 11 states possibly compensate for tinnitus (Sataloff 2006). Our contact in Washington replied that “Tinnitus is ratable only in the presence of a compensable hearing loss. If there is a measurable hearing loss, tinnitus will be added to the award based upon the latest version of the AMA (American Medical Association) Guides to the Evaluation of Permanent Impairment. In rating tinnitus, the physician will add up to 5% (depending on severity) for each ear with compensable hearing loss. This is a one-time award. If the worker files a future claim and has further hearing loss he cannot be awarded any further award for tinnitus”.

From the same overview (Sataloff 2006) we found that in Canada most provinces require an accepted occupational hearing loss claim and persistence of tinnitus for over 2 years. In Ontario, the condition also requires its confirmation by an otolaryngologist with facilities for the testing of tinnitus. The authors comment that this is difficult for a subjective complaint. Most awards appear in the 2% permanent impairment range across Canada except under unusual circumstances (e.g. severe psycho-traumatic disability as a result of the tinnitus). Where severe and bothersome tinnitus exists in the presence of a unilateral hearing loss it may impair an individual's speech discrimination: under these circumstances awards are often increased to a 3-5% permanent impairment level.

Table: Policies for compensation for tinnitus in other countries and other states of Australia

Country/ State	Is tinnitus considered for additional hearing loss?	In what circumstances is tinnitus considered for additional hearing loss and to what extent?
UK	yes	Discretion exists to allow the decision maker, on the basis of the clinical judgment of a medical advisor, to increase the disablement assessment to reflect the effects of tinnitus. Severe tinnitus is likely to increase the amount of disablement resulting by NIHL by 5-6%.
France	no	No, tinnitus is not obligatory considered for additional hearing loss; the list states: "hearing loss of perception with or without tinnitus"
Netherlands	not applicable	Tinnitus may cause loss of concentration and therefore can cause a problem for a worker to function. This will be evaluated, but to what extent worker disability is compensated is up to the specialists involved.
Germany	no	No, normally not.
Singapore	no	No, additional compensation is given for tinnitus
Taiwan	no	No, tinnitus is not considered to be additional hearing loss
Ontario	yes	Tinnitus can be considered as a further impairment or disability. Policy 16-01-08 Tinnitus, Post-January 2, 1990 http://www.wsib.on.ca/wsib/wopm.nsf/Public/160108
British Columbia	no	no, additional compensation
USA	yes/ no	Although tinnitus (ringing in the ears) typically accompanies noise-induced hearing loss, only about half of the states and provinces responded that tinnitus is taken into effect when calculating awards.
Washington State	yes	Only if there is a measurable hearing loss, tinnitus will be added to the award based upon the latest version of the AMA Guides. In rating tinnitus, the physician will add up to 5% (depending on severity) for each ear with compensable hearing loss. This is a one-time award.
Finland	yes	In the new criteria (2009) tinnitus is mentioned. Mainly, it does not affect the percent, but in especially severe and permanent cases it may give the 1 class (5%) increase to the total impairment. If there is no hearing loss, no compensation exists for tinnitus alone.
VIC	no	
ACT	yes	Also follows the WorkCover NSW Guides 2001 on this topic.
ComCare	yes	up to 5% of disability caused by the hearing loss
NSW	yes	is included in the WorkCover NSW Guides 2001
NT	?	although hearing loss assessment is according to AMA guides 4 th Edition
NZ	yes	
QLD	yes	
SA	yes	WorkCover SA guides 2009
Seacare	yes	up to 5% of disability caused by the hearing loss
TAS	?	although hearing loss assessment is according to AMA guides 4 th Edition
WA	no/yes	not for NIHL, but it does for other types of hearing loss (WorkCover WA guides 2007)
Guidelines		
AMA 4 th Edition	yes	Tinnitus in the presence of unilateral or bilateral hearing loss may impair speech discrimination and an impairment up to 5% may be added to the impairment for hearing loss
AMA 5 th Edition	yes	Add up to 5% for tinnitus in the presence of measurable hearing loss if the tinnitus impacts the ability to perform activities of daily living.
AMA 6 th Edition	yes	If the tinnitus interferes with ADLs, including sleep, reading (and other tasks requiring concentration), enjoyment of quiet recreation, and emotional well being, up to 5% may be added to a measurable binaural hearing impairment.
ASOHN guidelines (concept June 2010)	yes	Tinnitus in the presence of unilateral or bilateral hearing loss may impair speech discrimination and an impairment up to 5% may be added to the impairment for hearing loss (based on AMA 4 th Edition)

Summary:

As there are no objective diagnostic tools to evaluate the severity of tinnitus it is difficult to measure the impact of tinnitus on quality of life and ability to work. Nevertheless, there are many studies to find in the medical literature that try to evaluate the potential impact of tinnitus and quality of life. We briefly described five recently published articles and the most appropriate guidelines to evaluate the impact of tinnitus and suitable compensation for the caused disability. We concluded that tinnitus can have an impact on quality of life mainly because of the emotional distress it can cause. Why some people suffer severely from tinnitus and others don't seem to be bothered remains unclear. Literature so far, suggests there may be an association with a predisposition for anxiety or depression but more research needs to be done.

The AMA guides 4th, 5th and 6th Edition all suggest including tinnitus in the evaluation for NIHL up to 5% of the binaural hearing impairment, and so does the ASOHNs guidelines in their concept version of June 2010.

There is no international consensus approach to tinnitus in compensation schemes. The information on how tinnitus is handled in workers compensation in foreign countries showed that approximately half of the countries or states (see table) may include tinnitus when evaluating hearing impairment for compensation. The majority of countries are in line with the AMA guides on this; if there is a severe case of tinnitus then the binaural hearing loss is increased with a small percentage (5%) and then converted into whole person impairment.

Overall Summary

Prevalence of tinnitus in workers exposed to noise at work varies considerably with the majority of retrieved studies not comparing their results with workers not exposed to noise. A dose-response relation between the severity of noise (exposure level and duration) and the frequency of tinnitus episodes was reported in 10 studies. Five studies measured actual noise exposure and the prevalence of tinnitus, and demonstrated different relationships. A problem is that three of these five studies did not investigate the occurrence of NIHL.

The majority of studies support the association between tinnitus and NIHL. The prevalence of tinnitus is higher for those with NIHL and hearing thresholds in those with tinnitus are higher. All but one study had a cross sectional design and therefore it remains unclear whether hearing loss and tinnitus occur as independent effects of noise exposure, or whether one is causally related to the other. The longitudinal study suggests there may be a causal relationship, but more research is necessary.

As there are no objective diagnostic tools to evaluate the severity of tinnitus it is difficult to measure the impact of tinnitus on quality of life and ability to work. Nevertheless, there are many studies to find in the medical literature that try to evaluate the potential impact of tinnitus and quality of life. We described five recently published articles and the most appropriate guidelines to evaluate the impact of tinnitus and suitable compensation for the caused disability. We concluded that tinnitus can have an impact on quality of life mainly because of the emotional distress it can cause. Why some people suffer severely from tinnitus and others don't seem to be bothered remains unclear. Literature so far, suggests there may be an association with a predisposition for anxiety or depression but more research needs to be done. The AMA guides 4th, 5th and 6th Edition all suggest including tinnitus in the evaluation for NIHL up to 5% of the binaural hearing impairment, and so does the ASOHNs guidelines in their concept version of June 2010. The information on how tinnitus is handled in workers compensation in foreign countries showed that approximately half of the included countries or states include tinnitus when evaluating hearing impairment for compensation. The majority of countries are in line with the AMA guides on this; the binaural hearing loss is increased with a small percentage (5%) and then converted into whole person impairment.

Recommendation

Based on the retrieved literature, the guidelines and the recommendations of both the AMA guides and the ASOHNS guidelines we recommend that tinnitus should be included in the evaluation of NIHL for compensation purpose by WorkSafe Victoria.

For compensation purposes we propose to follow the guideline as provided by the American Medical Association's Guides to the Evaluation of Permanent Impairment, 4th Edition as was also suggested in the ASOHNS guidelines. The AMA guides states that tinnitus in the presence of unilateral or bilateral hearing loss may impair speech discrimination and an impairment of up to 5%, depending upon severity, to be added to the percentage hearing loss, before being converted to the whole person impairment for hearing loss.

The following criteria should apply for tinnitus:

- (A) A link can be established between the tinnitus and the compensable hearing loss.
- (B) The tinnitus is continuous and sufficiently troublesome for the claimant to have sought treatment from a medical practitioner.
- (C) The percentage deemed appropriate for the tinnitus can then be added to the percentage loss of hearing before conversion to the Whole Person Impairment.

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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>
- for Finland: answers to questionnaire
- for British Columbia: from information by Dobie 2001