Quantification of the burden of disease for tinnitus caused by community noise

Background paper

PREPARED FOR THE
WHO SECOND TECHNICAL MEETING ON QUANTIFYING DISEASE FROM ENVIRONMENTAL NOISE

HOTEL AMBASSADOR, BERN, SWITZERLAND
15TH, 16TH DECEMBER 2005

World Health Organization Collaborating Center on Environmental and Occupational Health Impact Assessment and Surveillance

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Suggested citation :
Deshaies P, Gonzales Z, Zenner HP, Plontke S, Paré L, Hébert S, Girard SA, Normandin N, Leroux T, Zalaman IM (2005) Quantification of the burden of disease for tinnitus caused by community noise. Background paper. Available only in electronic version at http://www.chuq.qc.ca/oms/pdf/in06_188.pdf

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ACKNOWLEDGMENTS

The authors make a point of thanking Dr Richard S. Tyler, University of Iowa for his judicious comments and suggestions, to Mr Stephen Bly, Health Canada, for providing us with pertinent literature and to Mrs Sylvie Muller, INSPQ for her secretariat work.

ABSTRACT

Tinnitus caused by excessive noise exposure has long been described. Noise can lead to temporary or permanent hearing impairment (noise-induced hearing loss (NIHL)) and is frequently associated with tinnitus. Nevertheless, tinnitus may be experienced by a small percentage of persons exposed to excessive noise without measurable hearing loss. Because the natural history, the annoyance and disability, the clinical approaches for diagnosis and treatment as well as the consequences of tinnitus differ significantly from these same elements in persons with NIHL, this document presents key elements for the development of a valid method for quantifying specifically the burden of disease for tinnitus caused by community (environmental) noise exposure. This paper is the Background document used for a presentation at the World Health Organization Second technical meeting on Quantifying Disease from Environmental Noise held on December 15-16, 2005, at the Hotel Ambassador in Bern, Switzerland.

The proposed case definition is a sound perception that cannot be attributed to an external sound source and that causes some annoyance and/or disability. A noise exposure sources typology is suggested. The pathophysiology of tinnitus is revised and a causal web is presented. A thorough review of the epidemiological literature identified 23 studies meeting selection criteria. Prevalence of tinnitus varies from 3 to 36% due to variations in the cross-sectional study designs. Only two studies report incidence data. The natural history as well as age and sex distribution are revised. The literature on exposures causing tinnitus is discussed. Exposure-response relationship, causality, population attributable portion of tinnitus caused exclusively by community noise exposure, disability weights, cross-cultural issues as well as pending uncertainties are addressed.

RÉSUMÉ

On sait depuis longtemps que l'exposition excessive au bruit peut causer des acouphènes. Une telle exposition peut induire une perte auditive temporaire ou permanente, laquelle est fréquemment associée à des acouphènes. Cependant, un faible pourcentage d'individus peut souffrir d'acouphènes sans perte auditive après une exposition excessive au bruit. Puisque que l'histoire naturelle, la gêne et les incapacités, les approches cliniques pour le diagnostic et le traitement ainsi que les conséquences des acouphènes diffèrent significativement de ces mêmes éléments chez les personnes avec une perte auditive due au bruit, il est pertinent d'approcher séparément le calcul du fardeau de la maladie (charge de morbidité) des acouphènes causés par l'exposition au bruit communautaire (environnemental). La présente publication a servi de document de base à la présentation faite dans le cadre de la deuxième rencontre du comité technique de l'Organisation mondiale de la santé pour la quantification du fardeau de la maladie causée par le bruit environnemental. Celle-ci a été tenue à l'hôtel Ambassador de Berne, Suisse, les 15 et 16 décembre 2005.

La définition de cas proposée d'acouphène est la perception d'un son qui ne peut être attribué à une source sonore externe et qui cause de la gêne (nuisance) ou des incapacités. Une typologie des sources d'exposition au bruit est suggérée. Un état des connaissances sur la pathophysiologie des acouphènes est présenté ainsi qu'un modèle conceptuel. Une revue exhaustive de la littérature épidémiologique identifie 23 études rencontrant les critères de sélection. La prévalence des acouphènes y varie de 3 à 36% principalement à cause de la variabilité dans le devis des études transversales. Seules deux études présentent des résultats d'incidence. L'histoire naturelle de la maladie ainsi que la distribution selon l'âge et le sexe sont révisées. La littérature pertinente sur les types d'expositions causant les acouphènes est discutée. La relation exposition-réponse, la relation causale, la fraction des acouphènes dans la population générale attribuable exclusivement à l'exposition au bruit communautaire, les poids de l'incapacité (« severity weight »), la question de l'applicabilité des données de fréquence entre les cultures et pays ainsi qu'une liste des sujets nécessitant un approfondissement sont abordés.

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LIST OF INITIALS AND ABBREVIATIONS

Initials	Definition
CI	Confidence interval
DALY	Disability Adjusted Life Year
DW	Disability weight
ER	Exposure response
I	Number of incident cases
ICD	International classification of diseases
IR	Incidence
L	Standard life expectancy at age of death (in years)
Lm	Mean levels
MDS	Minimal data set
N	Number of deaths
NIHL	Noise-induced hearing loss
NIOSH	National Institute for Occupational Safety and Health
NIT	Noise-induced tinnitus
NOAEL	Non-observable adverse effect level
P	Prevalence
PAF	Population attributable fraction
PR	Prevalence rate ratio
PST	Prolonged spontaneous tinnitus
PTS	Permanent hearing threshold shift
RR	Relative risk
TQ	Tinnitus Questionnaire
YLD	Years lived with disability
YLL	Years of life lost due to premature mortality

1 INTRODUCTION

Tinnitus caused by excessive noise exposure has long been described (Holt, EE., 1882; Sataloff, J., 1952; Vernon, JA., 1995). Noise can lead to temporary or permanent hearing impairment with or without tinnitus. Excessive noise exposure is the major modifiable cause of permanent hearing impairment worldwide and an important public health priority because the estimated cost of noise in developed countries range from 0.2% to 2% of the gross domestic product (WHO-Report, 1997). Between 12 and 50% of persons with noise-induced hearing loss report having tinnitus (Sindhusake *et al.*, 2004; Kähäri *et al.*, 2003; Palmer *et al.*, 2002; Nondahl *et al.*, 2002). Tinnitus is very often found to be present concomitantly with hearing loss. This is also true for noise-induced tinnitus and noise-induced hearing loss (Vio, MM., Holme, RH., 2005; Eggermont, JJ., 2005). Nevertheless, tinnitus may be experienced by persons exposed to excessive noise without measurable hearing loss (Jones *et al.,* 1998). Several authors consider tinnitus as a symptom of the auditory system and not as a disease per se. On the other hand, tinnitus is a diagnosis in the International Classification of Diseases (ICD) ICD-9 (388.3) and ICD-10 (H93.1).

The natural history, the annoyance and disability, the clinical approaches for diagnosis and treatment as well as the consequences of tinnitus differ significantly from these elements in persons with noise-induced hearing loss (NIHL). For instance, insomnia reported by tinnitus sufferers is not a consequence of NIHL. Therefore, the authors consider it justified that tinnitus be analyzed *per se* as an independent outcome of noise-related burden of disease.

The scope of this document is to present the results of the working groups' recent work basically around steps 1 to 4 of the method proposed by Mathers *et al.* (2001). Further work will be needed to ultimately propose a method for quantifying the burden of disease for tinnitus caused by community noise-exposure.

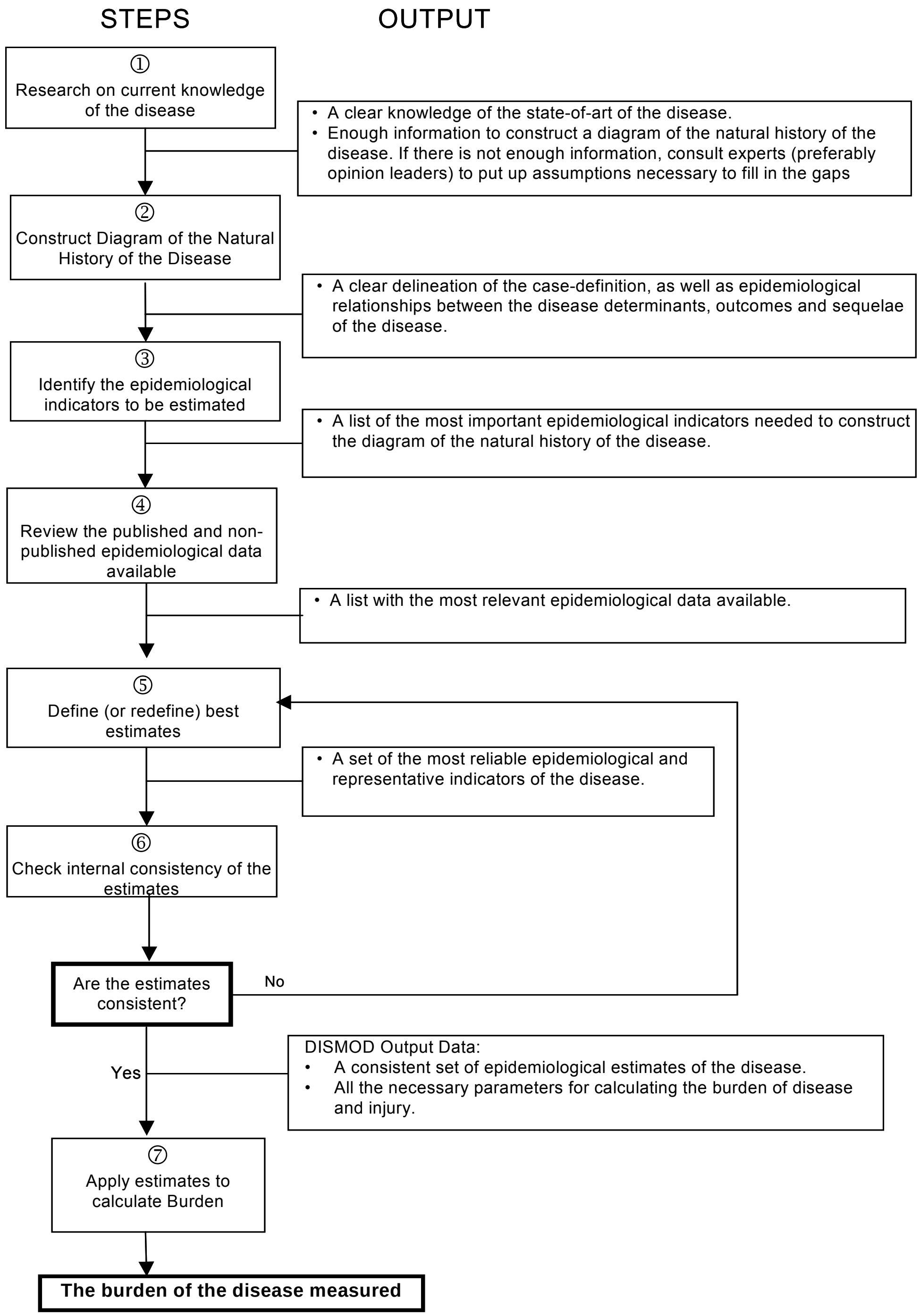


Figure 1 Developing a Reliable and Internally Consistent Epidemiological Assessment

Source: Mathers *et al.*, 2001

Although occupational noise is an important cause of tinnitus and is mentioned once but not considered as a relevant outcome in WHO document on the burden of disease for occupational noise (Concha-Barrientos *et al.*, 2004), it will only be discussed here as an aggravating factor to consider for community noise induced-tinnitus.

2 ESSENTIAL PRELIMINARY CONSIDERATIONS

2.1 DEFINITION OF TINNITUS

It is important to agree upon a working definition of tinnitus before considering its quantification in terms of burden of disease. There are several definitions of tinnitus in the published literature and according to different experts.

Tinnitus is the general term for sound perception (roaring, hissing or ringing) that cannot be attributed to an external sound source. In terms of auditory abilities, tinnitus is the inability to perceive silence, defined as the absence of external sound stimulus (Leroux *et al.*, 1993).

Tinnitus defined in such broad terms is rather prevalent. It is widely believed that mild, occasional tinnitus is experienced by nearly everybody at some time or another in his lifetime (MacFadden, D., 1982). There is considerable variation in tinnitus expression, its etiology, and its effect on patient's lives (Tyler, RS., 2000).

The lack of a clear understanding of a unique mechanism of generation and perception of tinnitus makes a single classification difficult to envisage. Tinnitus may be classified according to its different attributes : duration of a single episode (seconds, minutes; intermittent, continuous), longitudinal duration (days, months, years), severity (degree of annoyance, interference with daily living). For longitudinal duration, tinnitus may be classified as acute (≤ 3 months), subacute 3-12 months), and chronic (> 12 months) (German ENT Society: Natl. Guidele Tinnitus, 1998: http//www.uni-duesseldorf.de/WWW/AWMF/ll/017-064.htm). Dauman and Tyler proposed a classification according to 5 parameters of tinnitus : pathology, severity, duration, site and etiology (Dauman and Tyler *in* Tyler, 2000). Stephens and Hétu proposed a classification according to patient's abilities and quality of life (Stephens and Hétu, 1991). More recently, Dobie gives this interesting qualitative contour for tinnitus (Dobie, RA. *in* Tyler, 2006): «Some people who begin to notice tinnitus, whether spontaneous or induced by trauma, noise, or other insult, will experience spontaneous resolution, but many will have persistent tinnitus. For some of them, tinnitus sensation (the sound) will be joined by tinnitus suffering, with adverse effects on thinking, feeling, and other activities of daily life, including sleep».

The most often reported consequences of tinnitus or comorbidities are :

- Loss of control;
- Depressive moods, depression;
- Helplessness (despair);
- Sleep interference (difficulty getting to sleep; insomnia);
- Muscle tensions;
- Loss of attention;
- Anxiety;
- Hyperacusis;
- Headaches;
- Irritation;
- Interference with normal activities;
- Difficulty with listening;
- Difficulty with concentration.

Experts consider that tinnitus may be disturbing to such an extent that it can be a risk factor for suicide (Johnston *et al.,* 1996).

Tinnitus annoyance and experienced handicap can be measured on an individual basis by a variety of questionnaires. Severity grading classifications (grade I to grade IV) as measured by the Tinnitus Severity Questionnaire developed by Goebel *et al.* (1994), a German translation of the tinnitus annoyance questionnaire developed by Hallam, is probably one of the most frequently used tinnitus questionnaires in Germany. As far as evaluating the severity of tinnitus, three validated tinnitus self-rating scales together with the Tinnitus Questionnaire (TQ, according to Goebel-Hiller (German) and Hallam (English)) can be employed as part of “minimal datasets” to reflect the patient’s current tinnitus status (table 1). These tests are simple and easy to use and can be completed by the patient alone. The results are easy to interpret and provide a good foundation for an effective doctor-patient dialog (Zenner *et al.,* 2006).

Table 1 Minimal data set (MDS) to be used to assess degree of tinnitus (Zenner *et al.*, 2006)

Tests	before therapy	after therapy	validity	Reliability
TQ (Hallam et *al.* 1988; Goebel *et al.* 1994).	+	+	a	A
Tinnitus Loudness (6-point response scale)	+	+	a	A
Tinnitus Annoyance (8-point response scale)	+	+	a	n.a.
Tinnitus Change (6-point response scale)	-	+	a	n. ass.

(+ = included in MDS; - = not included in MDS; a = adequate., n. a. = not adequate. n.ass. = not assessed).

Clinically important is the categorization of the tinnitus according to the resulting disability in daily life (disability weight concept). Tables 2 and 3 display details of the categorizations by Goebel *et al.* (1994) and by Biesinger *et al. (1998).*

Table 2 Categorization according to Goebel *et al.* (1994)

Compensated (Balanced) Tinnitus Goebel-Hiller/Hallam-Score

Level 1 (light)	0-30
Level 2 (medium)	31-46

Non-compensated (unbalanced) Tinnitus

Level 3 (profound)	47-59
Level 4 (severe)	60-84

Table 3 Categorization according to Biesinger *et al.*, (1998)

Compensated (Balanced) (without secondary symptoms)
The patient perceives the tinnitus but is able to cope normally without the appearance of secondary symptoms

Level I:	No disturbances
Level II:	Occurs mainly during periods of calm/stillness; is disturbing under periods of stress or strain

Non-Compensated (Unbalanced) (secondary symptoms present)
The presence of tinnitus has serious impact on the patient's life and leads to the development of psychological problems (fear, sleep disturbance, lack of concentration, depression).

Level III:	There is a constant disturbance to the private and professional life of the patient. Secondary symptoms affect the emotional, cognitive, and physical state of the patient.
Level IV:	The presence of tinnitus leads to a complete imbalance in the personal life of the patient. Employment is no longer possible.

Other countries use different questionnaires. Questionnaires that have good psychometric properties (i.e., good internal consistency and test-retest reliability) are the Tinnitus Reaction Questionnaire (developed by Wilson *et al.*, 1991), which measures emotional tinnitus-related distress, the Tinnitus Handicap Questionnaire (Kuk *et al.*, 1990) which measures the self-reported severity of tinnitus as a handicap, and the Tinnitus Handicap Inventory (Newman *et al.*, 1996), which quantifies the impact of tinnitus on everyday life. The Tinnitus Reaction Questionnaire and the Tinnitus Handicap Questionnaire have been translated and validated in French (Meric, C., Pham, E. et *al.,* 1997; Meric, C., Pham, E., & Chéry-Croze, S, 2000).

In epidemiological studies, questions are sometimes asked about tinnitus duration or severity (degree of annoyance). Psychoacoustical measurements of tinnitus can also be made. Because tinnitus is a sound perception, it can be matched in loudness and frequency with an external sound. Usually, studies that have reported such loudness-pitch matching have found that tinnitus loudness estimates usually fall between 0 and 10 dB SL (the later corresponding to more than a doubling in loudness perception) in most subjects (Vernon *et al.*, 1988; Tyler, RS., 2000). Tinnitus pitch varies somewhat more across and within subjects, but mostly corresponds to frequencies at which a hearing loss is present (Henry *et al.*, 1999). Methodological issues may contribute to this variability. A recent study found that when the procedure allows assessment of various pitch components, tinnitus is revealed to be composed of a broad frequency spectrum falling into the hearing loss range, despite feelings of unitary pitch sensation (Norena *et al.*, 2002). Yet, psychoacoustical measurements typically do not predict the psychological distress reported by patients (Møller, AR., 2000).

When considered, populational epidemiological studies usually have used simple questions about duration and the degree of annoyance rather than the tools described previously to assess the individual status.

Finally, according to RS Tyler (2000), at least two elements should be included into any demographic (epidemiological) study :

- Tinnitus that lasts for five minutes or more (additionally whether it is present some or all the time);
- An assessment of the impact of the tinnitus (for example, severity or annoyance).

Given the previous elements presented, the following working definition for burden of disease purposes is proposed.

A sound perception (e.g. whistling, roaring, hissing or ringing) that cannot be attributed to an external sound source and that causes some annoyance and/or disability.

2.2 NOISE TYPOLOGY

Community noise is a rather broad category embracing many sources of noise exposure in a variety of settings. Furthermore, prevention strategies may differ considerably according to sources (regulations, policies, target populations). The following classification will be used throughout this document.

The most well-known noise sources are :

- Traffic noise (cars, planes, trains, motorcycle);
- Construction noise;
- Urban and community noise (neighbours, radio, television);
- Social/leisure noise (cassettes, fireworks, toys, rock concerts, firearms, snowmobile, motomarine).

2.2.1 The Combination of Environmental and Occupational Noise

Many adolescents and young adults work in noise-polluted environments and additionally expose themselves to social noise during their leisure, i.e. nonworking time. Because of the occupational and social noise, the rest periods needed by the hearing system are reduced. This affects particularly the 10 % subpopulation of an age group mentioned below (section "leisure noise"), since there is a higher incidence of poor schooling and low social status, unskilled occupations in noisy workplaces combined with excessive exposure to leisure noise (Plontke *et al.*, 2004a). Consequently, these people perform simple occupational tasks in a noise-polluted environment and expose themselves to more social noise as well. An individual working in a job within a noisy environment needs an aural recuperation phase of at least ten hours at below 70 dB(A) (Zenner *et al.,* 1999a). According to other authors, the ideal time for aural recuperation would be double the exposure time (e.g. for an 8 hour noise exposure, a 16 hour recuperation time). However, some authors mention that aural recuperation must be at least equivalent to exposure time. There is no general consensus about this particular point.

When evaluating individual risk for a person exposed to specific noise levels, it should not be forgotten that a limit exposure level can only provide a protective effect if hearing can recover for a sufficiently long period after the sound event (for instance after an 8-hour work day). This means that a certain recovery time (at least e.g. 10 h) with a sound level lower than 70 dB(A) is adhered to after work (Unfallverhütungsvorschrift (UVV) Lärm, Federal Republic of Germany, 1997). Protective measures are only then effective if the recovery times are adhered to and noisy recreational activities are not indulged in. The authors are not aware of any study looking into the cumulative health effects of occupational and non occupational noise exposures.

2.3 PATHOPHYSIOLOGY

Most cases of tinnitus are of unknown origin. Among known factors such as acoustic neurinomas, presbyacousis, intoxications and noise, the reported frequency of occurrence for the later is anywhere between 50 and 90% (Spoendlin, H., 1987, *in* Tyler, 2000). A very small proportion of tinnitus cases signal the presence of an underlying treatable medical condition, such as a tumor or chronic partial opening of the Eustachian tube, but the majority of cases has no apparent or treatable cause, and primarily produce psychological distress and annoyance.

There is no single pathophysiological pathway to explain the production of tinnitus. All structures of the auditory system have been suggested as possible sites of generation for tinnitus, from periphery to auditory cortex. Many explanatory models have been proposed either based on anatomical, physiological, clinical or neuropsychological approaches. Underlying mechanisms responsible for transient and chronic tinnitus are also most likely different (Eggermont, JJ., 2005). Despite those limits in understanding the pathophysiology of tinnitus, there is no doubt that noise can cause incapacitating tinnitus (Eggermont, JJ., 2005; Plontke, *et al.,* 2002)

Important principles of central neurophysiological tinnitus processing are that individual tinnitus appraisal is directly linked to neuronal networks in the brain responsible for the production of emotions, perceptions and cognitions. Among different proposed neurophysiological models, the authors briefly describe the two following: the conditioned reflex model (Jastreboff, PJ., 1990) and the sensitization model (Zenner *et al.*, 2004) (see also Llinas *et al.*, 2005; Eggermont *et al.,* 2004 for other models). The conditioned reflex model predicts that repeated temporal associations of tinnitus and emotions produce conditioned reflexes resulting e. g. in fear. According to the sensitization model, cognitive processes may be associated with a reduction in the tinnitus cognition threshold, resulting in hypersensitivity of cognition. The sensitization contributes to the extremely loud cognition of the tinnitus signal.

For noise induced hearing loss and noise induced tinnitus, it can be assumed that genesis is based on the same hearing pathophysiology (Zenner *et al.*, 2002; Pujol *et al.*, 1999; Puel *et al.,*1995; Pujol *et al.*, 1993).

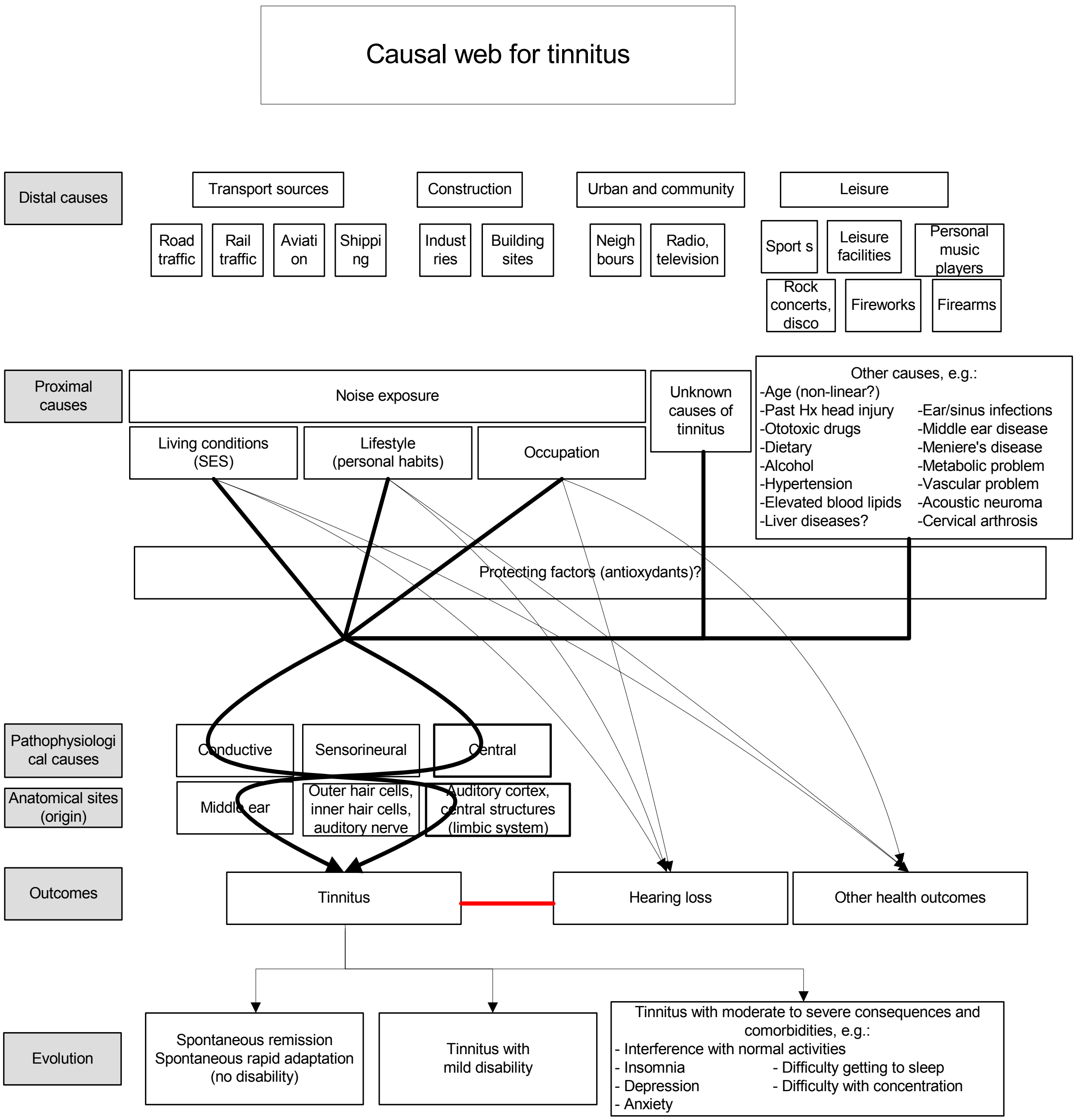
In a large study where 1 625 patients were asked to report whether their tinnitus onset was associated with some factor (circumstantial, drug-related, etc), a little less than half (N=693) reported no associated factor, about half (N=804) reported one associated factor, and a few (N=128) reported more than one associated factor. Among the ones who reported only one associated factor, 28.8% (N=468) reported a traumatic factor (as opposed to medical conditions), among which 19.9% was noise-related (11.3% long-duration noise, 3.3% brief, non-explosive noise, and 5.4% explosion such as fireworks or gunfire). Another 3.7%

mentioned a noise-related cause when more than one factor was reported (http://www.tinnitusarchive.org/dataSets/set-1/tinnitusHistory/onsetFactorsReported).

The following figure presents a causal web for tinnitus, with a particular emphasis on its relation to noise exposure.

2.3.1 Causal web for Tinnitus

Table 4 Causal web for Tinnitus



3 EPIDEMIOLOGY

3.1 OUTCOME

Published documents, experts' unpublished documents and opinions were assessed as documentary sources. The various research strategies on Medline (PubMed) retrieved more than 400 published studies in English, French, Spanish or German. From that first extraction, 99 were selected as being potentially of interest. A global quality assessment based on a pass or fail classification of the studies was done according to external validity, internal validity and data analysis criteria by the Quebec research agent who retained 23 epidemiological publications of interest from the initial lot. The following table gives a summary of these studies.

All 23 studies have a cross-sectional descriptive part and two present incidence results (longitudinal design). One study has an analytical part with relative risk for non-occupational noise exposure. As stated before, the operational definition of tinnitus used varies greatly from one study to another. This may partly explain the variability in prevalence results.

According to a recent population based random sample study, Germany has about three million people aged 10 years or over with tinnitus (Pilgramm *et al.*, 1999). About 1.5 million have problems with tinnitus and 800 000 suffer so severely that they are in continuous medical treatment. Interestingly, the authors were able to estimate an incidence rate of tinnitus in Germany of 0.33% of the total population per annum, for an estimated 250 000 persons becoming yearly new chronic patients suffering from tinnitus (Pilgramm *et al.*, 1999).

Table 5 Summary of major epidemiological studies and results for Tinnitus

Author(s) Publication year	Study year(s)	Population (age groups) [sampling]	Country	Questions / Definitions	Design	Outcome measure (type*)	CI95	Disabling tinnitus	CI95	Noise exposure OR population attributable fraction (PAF)
Adams *et al.*, 1999	1996	63 402 (All ages) [Random sample]	USA	"Does anyone in the family now have Tinnitus or ringing in the ears?"	Cross-sectional descriptive	3% (P) < 45 years 1% 45-64 years 6% ≥ 65 years 9%	-	-	-	-
Axelsson *et al.*, 1989	1980s	3 600 (20-80 years) [Random sample]	Sweden	"Do you suffer from tinnitus?" (Never/Seldom/Often/Always)	Cross-sectional descriptive	14,2% (P)	-	"Plagues me all day": 2,4%	-	-
Begault *et al.*, 1998	*Missing data*	64 pilots of commercial airline (*missing data*) [*Missing data*]	USA	"Do you have a buzzing, ringing, or whistling in one or both ears (tinnitus)?" (Frequently/Occasionally/Rarely/ Never)	Cross-sectional descriptive	29,5% (P)	-	-	-	-
Chung *et al.*, 1984	*Missing data*	30 000 workers (*missing data*) [Random sample]	Canada	"Do you have ringing in your ears?" (Yes/No)	Cross-sectional descriptive	6,6% (P)	-	-	-	-

Table 5 Summary of major epidemiological studies and results for Tinnitus (suite)

Author(s) Publication year	Study year(s)	Population (age groups) [sampling]	Country	Questions / Definitions	Design	Outcome measure (type*)	CI95	Disabling tinnitus	CI95	Noise exposure OR population attributable fraction (PAF)
Coles, RRA., 1984	1978-1981	Phase I: 8 069 Phase II: 7 645 (> 17 years) [Random sample]	United Kingdom	Ringing or buzzing lasting 5 minutes or more, excluding those occurring only after exposure to loud noise.	Cross-sectional descriptive	Phase I: 11% (P) Phase II: 10,6%(P)	-	5.6-7.4% interference with getting to asleep Phase I: Moderately (4%) or severely (1%) annoying: 5% Sleep disturbing: 5% Phase II: Severe effect on quality of life: 1%	-	-
Girard *et al.*, (unpublished data), 2005	1983-1996	41 631 (25-64 years) [convenience sample – blue-collar workers]	Canada	"Do you currently have continuous buzzing or whistling in one or both ears?"	Cross-sectional descriptive and analytical	5.2% (P) Adjusted PR (number of years exposed) PR(0)=1.00 PR(1)=1.03 PR(2-4)=1.11 PR(5+)=1.18 Linear trend Adjusted PR exposed/unexp. PR=1.09	0.93; 1.15 1.00; 1.23 1.03; 1.35 p=0.029 1.01; 1.19	-	-	PAF: 4.6%

Table 5 Summary of major epidemiological studies and results for Tinnitus (suite)

Author(s) Publication year	Study year(s)	Population (age groups) [sampling]	Country	Questions / Definitions	Design	Outcome measure (type*)	CI95	Disabling tinnitus	CI95	Noise exposure OR population attributable fraction (PAF)
Hannaford *et al.*, 2005	1998-1999	15 788 (>13 years) [Nationwide random sample]	Scotland	"Noises in the head or ears which usually lasted more than five minutes"	Cross-sectional descriptive	17% (P)	16.4-17.6%	Moderate annoyance: 17,4% Severe annoyance: 7,3%	-	-
Holgers, KM., 2003	*Missing data*	964 (7 years) [First 964 children of audiometric screening procedure of the ordinary school health service in Göteborg]	Sweden	(1) "After listening to loud music or other loud sound/noise, have you afterwards heard a ringing, buzzing or other sort of noise in your ears, even if the loud music or noise has been turned off?", (2) "Have you heard a ringing, buzzing or other sort of noise in your ears, without first having listened to loud music or other loud sounds?"	Cross-sectional descriptive	12% (P)	-	-	-	PAF: 2,5%
Johansson *et al.*, 2003	1998	590 (20-80 years) [Random sample]	Sweden	(1) "Do you have permanent tinnitus (permanent sounds in the ear, like pure tones or noise)?" (2) "Do you have periodically recurrent (spontaneous sounds in the ear, like pure tones or noise, that last for more than five minutes: not temporary sounds connected with alcohol consumption or very loud sound exposure)?"	Cross-sectional descriptive	13,2 % (P)	10.5-16.0%	-	-	-

Table 5 Summary of major epidemiological studies and results for Tinnitus (suite)

Author(s) Publication year	Study year(s)	Population (age groups) [sampling]	Country	Questions / Definitions	Design	Outcome measure (type*)	CI95	Disabling tinnitus	CI95	Noise exposure OR population attributable fraction (PAF)
Jokitulppo *et al*., 2002	1996	1 323 (25-55 years) [Random sample]	Finland	*Missing data*	Cross-sectional descriptive	12% (P)	-	-	-	-
Kähäri *et al*., 2003	*Missing data*	39 musicians (26–51 years) [convenience sample]	Sweden	Definition: Spontaneous or evoked sensation of sounds, e.g. ringing or buzzing, often combined with pure tones that occur in the absence of an external sound source. The different sounds could be uni or bilaterally located in the ears, or experienced and located somewhere in the head	Cross-sectional descriptive	48% (P)	-	-	-	-
Mercier *et al.*, 2003	2001	601 individuals attending an open concert (*missing data*) [convenience sample]	Switzerland	*Missing data*	Cross-sectional descriptive	"Post exposure tinnitus": 36% (P)	-	-	-	-
Nondahl *et al.*, 2002	1998-2000	3 737 (48-92 years) [All residents of Beaver Dam, Wisconsin]	USA	(1) "In the past year have you had buzzing, ringing, or noise in your ears?" (No/Yes/ Unknown); (2) "How severe is this noise in its worst form?" (Mild/Moderate/Severe/ Unknown); (3) "Does this noise cause you to have problems getting to sleep?" (No/Yes/Unknown)	Cross-sectional descriptive and 5-year follow-up	Cross-sectional 8,2% (P) 5-year follow-up 5,7% (IR)	7.4-9.1% 4.8-6.6%	-	-	-

Table 5 Summary of major epidemiological studies and results for Tinnitus (suite)

Author(s) Publication year	Study year(s)	Population (age groups) [sampling]	Country	Questions / Definitions	Design	Outcome measure (type*)	CI95	Disabling tinnitus	CI95	Noise exposure OR population attributable fraction (PAF)
Olsen Widén *et al.*, 2004a	*Missing data*	1 238 (13-19 years) [Voluntary participation of students from eight schools in Göteborg and Vanesborg]	Sweden	"Permanent Tinnitus" Question: "Do you have permanent tinnitus (buzzing or ringing) in your ears all the time?" (Yes/No) "Temporary Tinnitus" Question: "Have you ever had temporary tinnitus continuing for 24 hours or longer?" (Yes/No)	Cross-sectional descriptive	8,7% (P) 21.6% (P)	-	-	-	-
Palmer *et al.*, 2002	1997-1998	12 907 (16-64 years) [Random sample]	United Kingdom	"During the past 12 months have you had noises in your head or ears (such as ringing, buzzing, or whistling) which lasted longer than five minutes?"	Cross-sectional descriptive	Global: 4,5% (P) Men 6% (P) Women 3% (P)	-	-	-	Occupational noise exposure Men 36% Women 21%
Paré *et al.*, 2000	1998	12 000 households (>15 years) [Random sample of Quebec province population]	Canada	"Do you hear ringing, buzzing or whistling noises in your ears or head that last 5 minutes or more at a time?" "How often do you hear theses noises?" "Do these noises bother you?" "Have you ever consulted a health professional for these noises?"	Cross-sectional descriptive	12,9% (P) of total population	-	Annoyance: Tinnitus that bothers moderately: 2.3% Tinnitus that bothers a lot: 1.3%	-	-

Table 5 Summary of major epidemiological studies and results for Tinnitus (suite)

Author(s) Publication year	Study year(s)	Population (age groups) [sampling]	Country	Questions / Definitions	Design	Outcome measure (type*)	CI95	Disabling tinnitus	CI95	Noise exposure OR population attributable fraction (PAF)
Parving *et al.*, 1993	1985-1986	3 387 men, (53-75 years) [convenience sample]	Denmark	"Do you experience tinnitus of > 5 minutes' duration?" (Yes/No)	Cross-sectional descriptive	17% (P)	-	Annoyance (interference with sleep, reading and/or concentration): 3%	-	-
Pilgramm *et al.*, 1999	1998-1999	7 409 (>9 years) [random sample]	Germany	(*Missing data*; 45 questions about tinnitus)	Cross-sectional descriptive	24.9% (ever) (P) 13% (>5 minutes) (P) 3.9% (at the time of study) (P) 0.33% population new cases per year (IR)	SD=0.35%	2.0% (moderately serious to unbearable) (P)	-	-
Roberts, J., 1968	1959-1962	6 672 (18-79 years) [Random sample]	USA	(1) "At any time over the past few years, have you ever noticed ringing (tinnitus) in your ears, or have been bothered by other funny noises in your ears?" (Yes/No); (2) "How often?" (Every few days/Less often); (3) "Do they bother you?" (Quite a bit/Just a little)	Cross-sectional descriptive	32.4% (P)	-	-	-	-
Rosenhall, U., 2003	1971-1993	1 485 (>70 years) [Random sample]	Sweden	*Missing data*	Cross-sectional descriptive	"Continuous tinnitus" 12% (P)	-	-	-	-

Table 5 Summary of major epidemiological studies and results for Tinnitus (suite)

Author(s) Publication year	Study year(s)	Population (age groups) [sampling]	Country	Questions / Definitions	Design	Outcome measure (type*)	CI95	Disabling tinnitus	CI95	Noise exposure OR population attributable fraction (PAF)
Sanchez *et al.*, 1999	1992-1994	1 453 (70-103) [Random stratified sample]	Australia	Wave 1 (1) "Do you have ringing or other noises in your ears and head?" (Yes/No); (2) "How often do you hear ringing or other noises?" (Occasionally - less than once per week/ Frequently - more than once per week/Constantly) Wave 3 (3) "Do you ever get noises in your head or ears which usually last longer than 5 minutes?" (No, never/Some of the time/Most or all of the time)	Cross-sectional (wave 1/1992) and 2-years follow-up (wave 3/ 1994)	Tinnitus: Wave 1 only: 10,5% (P) 2-years follow-up: 7,0% (IR)	-	-	-	-
Sindhusake *et al.*, 2004	1997-1999	2 015 (55-99 years) [all persons living in two suburban postcode areas west of Sidney]	Australia	"Have you experienced any prolonged ringing, buzzing or other sounds in your ears or head within the past year, that is, lasting for 5 minutes or longer?" (Yes/No)	Cross-sectional descriptive	30% (P)	-	Dizziness Severe tinnitus:61,9% Mild tinnitus:47% (P of those with tinnitus)	-	Work exposure: - None (reference) - Tolerable 9,3% - Unable to hear speech 4,3%
Williams *et al.*, 2004	*Missing data*	136 (20-65 years) [convenience sample]	Australia	*Missing data*	Cross-sectional descriptive	10% (P)	-	-	-	-

Type*: IR=Incidence; P=Prevalence; PAF=Population attributable fraction; PR= Prevalence rate ratio; RR= Relative risk; SD=Standard deviation.

Cross-sectional studies have important limitations as they can't assess the evolution of the problem in terms of fluctuations in duration and severity. The following figure presents the natural history of tinnitus annoyance over time. (Tyler, RS., 2000)

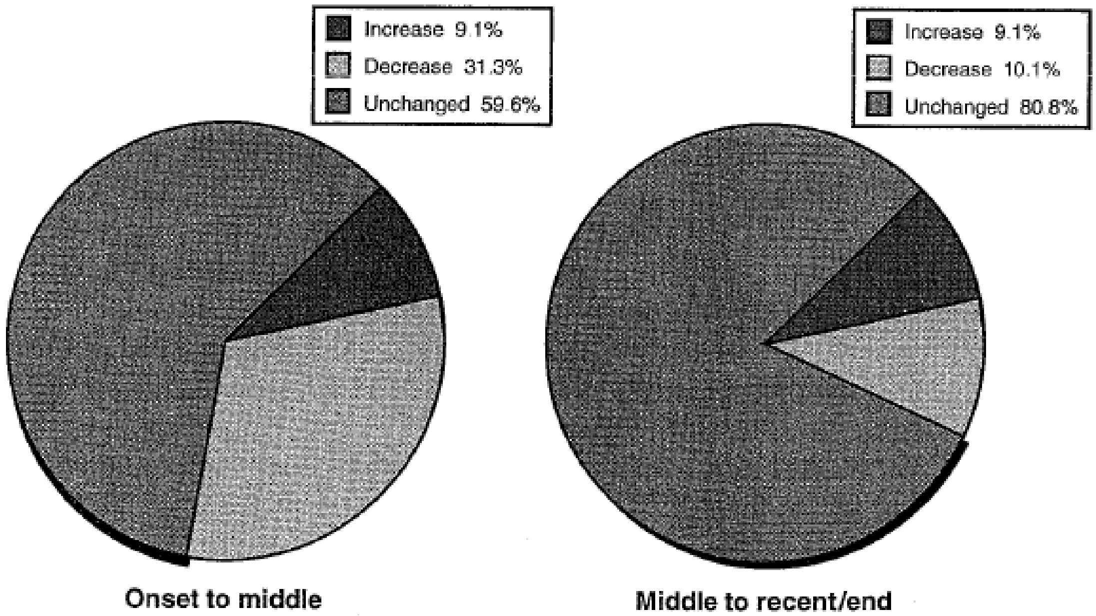


Figure 2 Tinnitus natural history, Annoyance change over time

Source: Tyler, RS., 2000, p. 18

Frequently reported difficulties experienced by tinnitus sufferers are sleep disorders (80% of 2.4 million German patients diagnosed with tinnitus). Most complaints range from being unable to fall asleep as to being woken up by tinnitus and unable to go back to sleep (Coles, RRA., 1984, Tyler *et al.*, 1983). This is followed by anxiety disorders and depressive moods characterized by the fear of an uncontrollable tinnitus. Another reported symptom is the subjective experience of difficulties with speech perception and attention. People report more problems with annoyance, irritation and the inability to relax.

From 30 patients being treated for acute acoustic trauma with acute tinnitus from new years firecrackers exposure, at least 8 (27%) were still suffering from tinnitus one year after the incident (Plontke *et al.,* 2003). These data are consistent with findings of Mrena *et al.* (2002). In this longitudinal study the authors observed 418 military recruits in Finland who were treated for acute acoustic trauma during their military service. Sixty-six (16%) still had tinnitus after 10 to 15 years. From their study, the authors concluded that in some cases tinnitus might be an even more serious threat to life satisfaction than mild hearing impairment.

3.1.1.1 Tinnitus and age

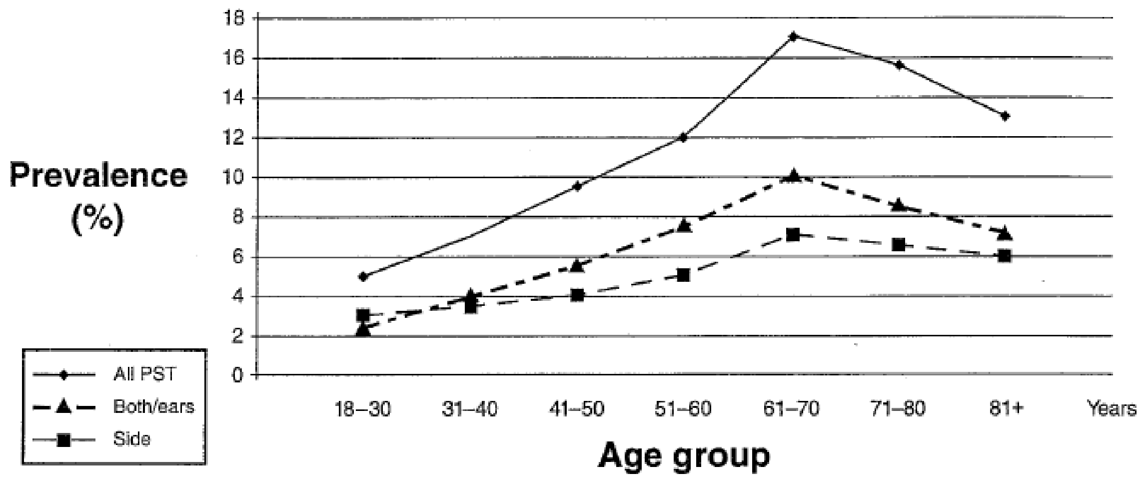


Figure 3 Prevalence of prolonged spontaneous tinnitus (PST) as a function of age and side of tinnitus

Source: Tyler, RS., 2000, p. 14

This figure shows the general trend for the relationship between tinnitus prevalence and age most often reported in studies. Some studies show a continuous increase after 60 or 70 years old.

3.1.2 Children

Prevalence of chronic tinnitus was estimated to be 29-60% in hearing impaired children between the ages of 12 to 18 years (Graham, JM., 1987) (see also Tyler, RS., 2000, chapter 10 Tinnitus in Children).

In children with normal hearing, the prevalence of tinnitus has been reported to be between 6% and 36% and much higher in children with hearing loss. In an epidemiological study in 7 year old school children (n=964), Holgers (2003) reported a prevalence of tinnitus of 12%. In contrast to other reports, hearing loss did not correlate to the prevalence of tinnitus and no gender differences were found. Noise exposure was suggested to be the cause of tinnitus in 2.5% of the children. The author concluded that persistent tinnitus in children may have similar causes to that in adults.

Kentish *et al.* (2000) reported in a preliminary (pilot) study with 24 children presenting to the Psychology Department with troublesome tinnitus that tinnitus can have as marked an effect on children's lives as it is reported to have on adults. The authors found insomnia, emotional distress, listening and attention difficulties as the main psychological factors associated with tinnitus in children with a secondary effect upon their school performance.

3.1.2.1 Tinnitus and gender

Table 6 Data on gender difference in the prevalence of tinnitus from four studies

Study	Population	Number	Percent Tinnitus	
			Male	Female
Leske (1981)	Civilian non-institutionalized population	6,672	29.7	34.9
Office of Population Census and Survey (1983)	Sample of population in private households, United Kingdom	23,000	13	16
Chung et al. (1984)	Noise-exposed workers in the United Kingdom	30,000	6.6	5.6
National Study of Hearing Phase II 1981–1982. Davis (1995)	Random sample of adults in four big cities in the United Kingdom.	7,645	10.2	11.0

Source: Tyler 2000, p. 12

Despite the variability in the results presented in previous table, the authors are not aware of any clinically or statistically significant differences in gender for noise-induced tinnitus. On the other hand, they are not aware of any study looking specifically into this issue.

3.2 EXPOSURE

When the sound level exposure regularly reaches or exceeds 90 dB(A), noticeable hearing impairments can be expected. If measured by conventional pure tone audiometry, sound pressure levels below 85 dB(A) have statistically only a low influence on hearing over the long-term. Exceptions include individuals with a vulnerable inner ear. However, this level is still capable of inducing measurable hearing-losses in high frequency ranges. Impaired hearing can start to appear in the range between 85 and 89 dB(A), but only after long exposure periods (VDI 2058, Blatt 2, VDI 2055 Blatt 2, 1988; Dierhoff, HG., 1976), or perhaps earlier with the predisposition of greater cochlear vulnerability. From 90 dB on a clear risk to hearing must be reckoned with. Tremendous environmental stress occurs with social noise that, contrary to other environmental noise, is generally demanded by the consumers.

A new risk assessment by the (US) National Institute for Occupational Safety and Health Cincinnati, Ohio (NIOSH, revised criteria, 1998) incorporating the 4 kHz audiometric frequency in the definition of hearing impairment reaffirms support for the 85 dB(A) recommended exposure limit for occupational noise exposure (85 decibels, A-weighted, as an 8-hour time-weighted average). With a 40-year lifetime exposure at 85 dB(A), the excess risk of developing occupational NIHL is 8% considerably lower than the 25% excess risk at the 90 dB(A) level.

Hearing impairment is not expected to occur at Laeq, 8h levels of 75 dB(A) or below, even for prolonged occupational noise exposure. It is also expected that environmental and leisure-time noise with a Laeq, 24h of 70 dB(A) or below will not cause hearing impairment in the large majority of people, even after a lifetime exposure (Berglund *et al.*, 2000).

If one is inclined to carry out calculations with noise levels, it should not be forgotten that the decibel (dB) is a logarithmic ratio unit. Thus an increase in rating level of 3 dB (e.g. from 90 to 93 dB(A)) represents a doubling in sound pressure. In other words, a two-hour stress with 93 dB(A) engenders the same sound energy as a four hour stress at 90 dB(A). An exposure at 105 dB(A), as is frequently encountered in discos, entails the same sound pressure dosis already after 4.8 minutes as an eight-hour noise exposure at 85 dB(A).

[NOTA BENE. The authors wish to debate the following hypothesis with the WHO expert group: although at the moment of writing this paper they did not have on hand empirical data to propose a non-observable adverse effect level (NOAEL) for noise-induced tinnitus (NIT), they believe that it is reasonable and plausible to use the same protective WHO NOAEL as for NIHL, being 75 dB(A) Laeq-8h and 70 dB(A) Laeq-24h. The authors wish the expert group's input for any additional empirical studies.]

Impulse noise can cause larger lesions inside the cochlea than continuous noise (20). The important criteria for noise-induced hearing impairments are sound levels, quick and steep increase of sound levels, duration of sound levels and individual vulnerability. Upon noise exposure comprising these factors individuals typically can experience tinnitus. Permanent irreversible cochlear impairment does occur with a permanent threshold shift (PTS) after recovery time and a permanent tinnitus is also possible. The permanent damage of the cochlea occurs frequently although it cannot be assessed with current diagnostic measures.

In most cases environmental noise does not reach the sound levels of occupational noise. One exception is social noise.

3.2.1 Children's Toys

Although to our knowledge there is no prospective studies on the risk for hearing loss or tinnitus from children's toys, based on a German expert panel consensus and case reports (Maassen *et al.*, 2001), there is no doubt that noisy toys increase the risk for hearing loss and tinnitus in children. The following table presents a list of children's noisy toys, which may cause hearing impairment. Toy weapons can reach sound levels up to and greater than 135 dB(A) at a distance of 1 meter from the exposed ear. When only 2.5 cm away from the ear then acoustic peaks of up to and greater than 163 to 173 dB(A) can be reached (Zenner *et al.,* 1999b). Toys making cracking noises are held very close to the ear by children and reach sound levels up to 135 dB(A) and small trumpets up to 125 dB(A).

Table 7 Noise from children's toys in dB(A); Results from randomly chosen German childrens' toys

Toy	Distance from the ear; sound pressure level in dB(A)	
	2.5 cm	25 cm
Carnival plastic trumpet "Trötttrompete"	116-117	100-104
Small trumpet	123-125	100-102
Single trumpet	109-116	92-100
Double trumpet	109-124	92-106
Indian trumpet		100-110
Signalling whistle	118-124	102-108
Trill whistle	126-128	112-114
Referee's whistle	127-129	107-109
Jumping cracker "Knackfrosch"	128-129	120-121
Other crackers "Knackfiguren"	134-135	120-122
Toy weapons		
Pistols	130-135	113-121
Pistols with caps "Streifenmunition"	>135	>135
Pistols with other ammunition "Knallplättchen"	>135	>135
Barrel revolver with cartridge "Amorces"	>135	>135
Air rifle with air compression	>135	130-135

Source : Zenner *et al.*, 1999b, European committee CENT/TC5L : « safety of toys »

The following noise pollution expected in Germany for adolescents and young adults is as follows :

- In discotheques the estimated standardized value will be Lm=90 dB(A); this sound level limit is much too high for a 10% subpopulation in each age group (95 dB(A)). (where Lm=median level);
- The median of Lm=78 dB(A) for portable cassette players and CD-players seems unproblematic but is actually a hazardous level for 10% of the population with a value of 98 dB(A).

Epidemiological studies on adolescents and young adults who have not been exposed to occupational noise have revealed an increasing amount of cases of verifiable irreversible cochlear damage. The most agreed upon plausible causes are the widespread availability of very noisy toys (pistols and fire crackers), fireworks as well as the ubiquitous availability of electro-acoustic amplifiers such as portable cassettes/CDs, music in discotheques or open air concerts (Maassen *et al.*, 2001).

Sound levels recorded in discotheques are generally between 92 and 111 dB(A) whereas headsets or earphones which can be inserted directly into the auditory canal have demonstrated maximum sound levels up to 120 dB(A) and average sound levels of 100 dB(A). This corresponds to the upper sound levels or more of a jack hammer. Another hazardous source is the loud speakers used during musical performances such as open air concerts or the like.

Maassen *et al.* (2001) presents interesting populational exposure data from Germany (see following 3 tables).

Table 8 Loud leisure noise activities of 18-19 year olds. Percentages are given in a representative group of 505 persons as well as the mean weekly and lifetime exposure.

	Percentage %	hour/week	Lifetime exposure in months
Visits to discotheques	79.7	6.2	30.6
Listening to loud music	71.9	11.4	44.3
Playing musical instruments	7.5	9.7	49.2
Motorbike, motor scooter	21.5	8.3	20.3
Other kinds of motor sports	2.5	9.5	12.8
Shooting sports	2.0	3.7	16.3
Others	2.6	7.4	40.2

Table 9 Mean levels Lm per year of occupational and non-occupational sound exposure and mean levels Lm per year for different exposure conditions

Source/exposed persons	Number of exposed persons in Great Britain	Yearly. L_m [dB(A)]
Discotheques		
(different estimations)	2 400 000	80-95
	600 000	>95
Industrial workers	2 600 000	>80
	600 000	>90

Source	Lm dB(A)* 10%	Lm dB(A)* 50 %
Discotheques		
highest estimation	95	87
lowest estimation	90	85
live Rock-concerts	91	83
Rock musicians	122	102
Listeners to PCP	86	77
Motorbike	81	

* Energy equivalent continuous sound level calculated for 1 year

Source: Maassen *et al.*, 2001, pages 5 and 9

The clinical suspicion that many young people have exposed themselves to situations hazardous to their hearing has been verified in a survey. In 1814 young German males 2/3 reported to have had tinnitus at least once. More than 2/3 of people who had gone to the discotheque reported that they experienced temporary tinnitus or a numbness of the ears (Babisch *et al*., 1988). The correlation between occurrence of tinnitus and discotheque variables was statistically significant. Two other studies by Meyer-Bisch, C. (1996) and Mori, T. (1985) demonstrated that 2/3 of the adolescents reported tinnitus after exposure to loud music.

In Canada, the authors found only one study of leisure exposure done on 269 students (Cheesman *et al.*, 2001). These authors questioned duration of exposure for the past seven days for 32 leisure activities capable of producing sound levels of 80 dB(A) or greater. Results are presented in the following table.

Table 10 Mean number of activities and total duration of participation in noisy leisure activities for the three student groups for the one week reporting period

	high school	college	university	all
number of activities	6.6	5.3	4.2	5.1
total duration (hrs)	24.4	20.2	19.5	20.7

Source: Cheesman *et al.*, 2001, page 42.

[Nota bene. We are currently in contact with US experts, but have been unable to gather populational data for this meeting; further work will be needed to cover this gap. The same applies for other countries.]

3.2.2 Exposure response (ER)-relationship

Analytical studies on community noise and tinnitus are very scarce. The authors only found the published studies cited in table 8 of Maassen *et al.* (2001). The results show the relationship between community noise exposure and permanent hearing threshold shift (PTS). We are in the process of verifying for similar analysis for tinnitus in the cited references of that table.

Table 11 Studies showing a correlation between music exposure and PTS

Author (year)	Comparison	Age (years)	Effect
Taylor (1976)	Music exposed/control	School leavers	PTS at 6 kHz 6.3 dB
Fearn (1981)	Music exposed /control	9 - 12 13 - 16 18 - 25	PTS (at 3 - 6 kHz) 1.5 dB " " 2 dB " " 3.3 dB " "
Fearn (1981)	Music exposed /control (1 year)	9 - 25	Relative risk for PTS ≥ 5 dB doubled
Fearn and Hanson (1984)	"	18-25	rel. risk of PTS ≥ 10 dB at 4 kHz proportionally increasing with the number of music events
Mori (1985)	Noise workers with music/ without music	20 - 24	PTS at 4 kHz = 5 dB PTS at 6 kHz = 9 dB
Babisch et al. (1988)	Disco Visitors/controls (4 times per month) Listening to music/control (≥3h/ day)	Boys 13 - 19 Girls 13 - 19 Boys 13 -19 Girls 13 - 19	PTS at 4 kHz = 5 dB PTS at 4 kHz = 4 dB PTS at 4 kHz = 3 dB PTS at 4 kHz = 4 dB
West and Evans (1990)		Young people	Correlation between music exposure and slight PTS
Struwe et al. (1996)	Disco visitor/ control Loud PCP/control	Recruits	rel. risk of PTS ≥ 20 dB RR = 1.3 (CI: 1.0 - 1.6)* RR = 1.8 (CI: 1.1 - 3.1)*
Meyer-Bisch (1996)	Disco /controls Rock concerts/controls PCP/control	15 -25	no difference PTS at 3 - 6 kHz PTS at 3 - 6kHz
Ising and Babisch (1998)	Disco + PCP / control	13 - 18	PTS at 3 -6 kHz depending on dosis, increasing to 8 dB (extreme exposure)
Mercier et al. (1998)	Music exposure $L_m \geq 85$ dB(A)for 5 years / $L_m < 85$ dB(A)	Pupils at trade school	rel. risk = 1.57 (CI 1.18 - 2.1)

Source: Maassen *et al.*, 2001, page 11

Girard et *al.,* very recently produced (2005) interesting preliminary results based on a large surveillance database of over 100 000 workers audition, labouring almost exclusively in industrial sectors, gathered through the occupational medical surveillance programs done by the Quebec Public Health Directions. In addition to individual hearing threshold levels, the database contains information from a questionnaire, applied shortly before auditory tests are performed, on individual occupational and extra-professional noise exposures, demographic and medical variables, including tinnitus. The questions for extra-professional noise exposure are :

- In a military setting, have you ever participated in firing exercises: YES/NO/UNCERTAIN-DONOTKNOW; if YES, how many firing sessions have you done?
- Have you ever done sport shooting? YES/NO/UNCERTAIN-DONOTKNOW; if YES, for how many years? On average, how many cartridges per year?
- Are you actually or have you been in the past been exposed for 4 hours or more per week to each of the following (number of years): snowmobile/motorcycle-“Quad”-VTT/farm vehicles/snowblower/hand power tools/loud music (disco, stereo, walkman)/chainsaw/others?

The question for tinnitus is :

- Do you currently have :
  - …
  - continuous buzzing or whistling in one or both ears?
  - …

This preliminary analysis was done on a subset of 44 320 male individuals aged 25-64 years tested between 1983 and 1996 who either had normal hearing or whose hearing loss was exclusively due to occupational noise. 2 689 (6.07%) workers had an unusable answer for tinnitus, leaving 41 631 workers for analysis. The prevalence of tinnitus is 5.2% (2173/41 631). The main adjusted results for different factors obtained with a Log-binomial regression model approach are presented in the following tables.

Table 12 Regression model #1* for the risk of tinnitus

Variables	Prevalence rate ratio	95% confidence interval
0 expo extra-professional	1,00	
≥ 1 year expo extra-professional	1,09	1.00707; 1.18671
Normal hearing	1,00	
Threshold of detectable (16 – 30 dB)	1,55	1.35756; 1.76675
Mild loss (31 - 40 dB)	2,35	2.01465; 2.75264
Moderate loss (41 – 50 dB)	3,72	3.18941; 4.32783
Severe loss (51 dB et plus)	6,58	5.73743; 7.54035
Occ. noise (< 90 dB(A))	1,00	
Occ. noise (≥ 90 dB(A))	0,99	0.91790; 1.08151
25 – 34 years old	1,00	
35 – 44 years old	0,87	0.76937; 0.98580
45 – 54 years old	0,83	0.71405; 0.97256
55 years old and over	0,87	0.71843; 1.04890
Occ. noise exposure duration (continuous)	1,01	1.00382; 1.01532

* Extra-professional noise exposure as a dichotomous variable

Table 13 Regression model #2* for the risk of tinnitus

Variables	Prevalence rate ratio	95% confidence interval
0 expo extra-professional	1,00	
≥ 1 year expo extra-professional	1.03	0.92688; 1.15314
2-4 years expo extra-professional	1.11	0.99820; 1.22892
≥ 5 years expo extra-professional**	1.18	1.03485; 1.35350
Normal hearing	1,00	
Threshold of detectable (16 – 30 dB)	1,55	1.35883; 1.76845
Mild loss (31 - 40 dB)	2,35	2.01507; 2.75322
Moderate loss (41 – 50 dB)	3,72	3.18601; 4.32350
Severe loss (51 dB et plus)	6,58	5.74449; 7.54941
Occ. noise (< 90 dB(A))	1,00	
Occ. noise (≥ 90 dB(A))	0,99	0.91820; 1.08186
25 – 34 years old	1,00	
35 – 44 years old	0,87	0.77200; 0.98937
45 – 54 years old	0,83	0.71971; 0.98082
55 years old and over	0,87	0.72334; 1.05644
Occ. noise exposure duration (continuous)	1,01	1.00363; 1.01513

* Extra-professional noise exposure in 4 categories.

** Only the 5 years and above extra-professional exposure category shows a significant CI95. The significant test for linear trend (p (linear-trend)=0,029) indicates a clear relationship between the risk of tinnitus and the number of years exposed to extraprofessional noise.

The highlights of this unheard of preliminary study are the following :

- There is a 10% risk of having tinnitus for individuals exposed to extra-professional noise for one year or more compared to those unexposed (<1year), after adjustment for occupational noise exposure level and duration, hearing level and age;
- There is a statistically significant linear relationship (dose-response curve) between duration of extra-professional noise exposure and the risk of having tinnitus, after adjustment for occupational noise exposure level and duration, hearing level and age;
- The calculated population attributable portion (PAP) for extra-professional noise-induced tinnitus in Quebec blue collar workers is 4.6% (55.8% of workers were exposed to non-occupational noise);
- These results probably underestimate the relative risk and therefore the PAP as the selection criteria exclude exposed workers that have mixed hearing loss.

NOTA BENE. One possible alternative approach the authors wish to discuss at the WHO expert meeting to get around this apparent paucity of direct analytical studies is the following: use the very well known dose-response relationship between occupational noise exposure and hearing loss; infer similar dose-response relationship for community noise exposure at equivalent dosis; estimate the percentage of tinnitus sufferers by level of NIHL; infer from there the risk of community noise tinnitus by noise-exposure level (per source).

Some elements for discussion are presented here. It is possible to estimate the proportion of the noise-exposed population that will acquire noise-induced hearing loss based on long-term exposure. The following table (Table 4) below indicates that a hearing loss (hearing thresholds averaged over 0.5, 1, 2 and 4 kHz) of 30 dB HTL will affect 9 % of the population after 40 years of exposure at 77 dB(A) for Laeq-8hours. If one consider a larger auditory impairment of 50 dB HTL, 0 % of the population will be affected at that same exposure level. The proportion of the population affected by a noise-induced hearing loss will increase with the sound level pressure.

Table 14 Hearing loss of 30 dB and 50 dB over 40 years as percentage of the population

	Noise level						
	77 dB(A)	82 dB(A)	87 dB(A)	92 dB(A)	97 dB(A)	105 dB(A)	115 dB(A)
% of population with 30 dB htl after 40 years	9	19	31	49	70	92	100
% of population with 50 dB htl after 40 years	0	1	4	9	17	37	73

Source: Robinson *et al.*, 1994

Tinnitus is a common experience following exposure to noise. Data from Jones *et al.* (1998) suggests that at least 25% of those people who report noise-induced hearing loss also report having tinnitus. A further 10% reported tinnitus in the absence of hearing loss.

3.2.3 Causality

Revised tinnitus literature seems to assume *de facto* a causal relationship between noise exposure and tinnitus. There seems to be little doubt among the experts about this causal relationship. Nevertheless, it is worthwhile to very briefly review Sir Austin Bradford Hill's criteria of causality (1965) :

- Strength [of the association]: based on available analytical studies, the strength of association between community noise exposure and tinnitus is not very high;
- Consistency [of the findings]: (this criteria is not applicable, as too few analytical studies are available);
- Specificity [of the association]: tinnitus is not a specific consequence of noise exposure; also, tinnitus is often of unknown origin;
- Temporality [lack of temporal ambiguity]: the acute nature of tinnitus appearance after acute exposures such as disco music or rock concerts gives good evidence of the temporal relationship, at least for acute exposure;
- Biological gradient [dose-response curve]: there is some evidence for a dose-response effect of occupational noise induced tinnitus (Sindhusake *et al.* 2004, others) and of a dose-response effect for community noise induced tinnitus (Girard *et al.*, 2005);
- [Biological] plausibility: although the exact pathophysiological pathway of tinnitus induced by noise exposure is not known, it is plausibly similar to the pathway for NIHL, at least for the onset of tinnitus, through damage to cochlear nervous cells; maintenance of tinnitus is still a matter of debate (brain cortex);
- Coherence [of the evidence]: the observation that noise can induce tinnitus is coherent with actual scientific knowledge;
- Experiment: experimental animal models tend to confirm that noise can induce ear damage that can generate tinnitus (Wallhäusser-Franke *et al.*, 1999; Mahlke *et al.*, 2004 ; Zhang *et al.*, 2003; Wallhäusser-Franke *et al.*, 2003);
- Analogy: the analogy with occupational noise induced hearing loss, the strong concomitant occurrence of hearing loss and tinnitus, makes analogies possible for community-noise induced tinnitus.

3.3 DISABILITY WEIGHTS

The authors are not familiar with disability weight (DW) methodology. According to their judgment, DW's should be determined with similar methodologies as those used for conditions such as chronic pelvic pain and low back pain, as tinnitus could be comparable to these conditions. Therefore, the following elements should be interpreted with caution as they propose preliminary DW's according to our understanding of this issue.

The DW proposed by the working group are based on their own expert judgment, using analogies with the available DW's sent to the group by WHO Bonn's office. They have not been discussed thoroughly. Therefore, the proposed DW should be seen as a first draft. Validation of these suggested DW need to be done in the future through validated processes.

The group recommends two DW to match with which ever data is available for calculation: one for general tinnitus prevalence data, one for annoying (disabling) tinnitus to match the proposed working definition.

For moderate to severely annoying tinnitus, the analogy is made with chronic pain. Chronic pelvic pain has a DW of 0.122 (GBD 1990 *in* Annex A, WHO document) whereas low back pain caused by chronic intervertebral disc has a DW of 0.121 (range 0.103-0.125) (GBD, 1990 or Netherlands weights *in* Annex A, WHO document). Primary cases of insomnia have a DW of 0.100 while a mild depressive episode has a DW of 0.140. As tinnitus may induce in some cases any of these two consequences, an interpolation in those ranges seems reasonable. Thus, a DW of 0.120 is suggested. On could argue that this DW could be used for any annoying (disabling) tinnitus, including mildly annoying tinnitus.

For global prevalence of tinnitus without reference to its severity, a global disability weight of 0.012 is suggested as a majority of people declaring tinnitus in surveys will either have spontaneous remission or adapt easily. Globally, the group believes that it should not be a null disability weight, as it is for mild adult onset hearing loss. On the other hand, only a small proportion of persons reporting ever having tinnitus will be disabled. Based on an estimated 10% who become moderate to severe sufferers, a DW of 0.012 seems logical.

3.4 UNCERTAINTIES:

NB. All uncertainties have been discussed elsewhere :

- Uncertainties with tinnitus definition;
- Uncertainties with consequences of tinnitus and quantification;
- Uncertainties with attributable portion of noise induced tinnitus;
- Uncertainties with exposure-response curves;
- Uncertainties with transcultural aspects of tinnitus;
- Uncertainties with severity weight estimations.

3.5 CONSIDERATION OF CROSS-CULTURAL GENERALIZABILITY OF DERIVED ER CURVE

Can we infer similar prevalence and natural history for tinnitus in different cultural settings? What about the risk of tinnitus from similar exposures? Can we infer similar disability weights? Possibly not…

Some experts are convinced that the burden of tinnitus is influenced by the cultural situation. The burden may be higher in cultures with frequent highly demanding professional work, where tinnitus may contribute to unacceptable mistakes.

3.6 EXAMPLE OF CALCULATION OF THE BURDEN OF DISEASE FOR EUROPE

[Might be completed at the meeting by Prof. Zenner et *al.,* if data available].

3.7 CONCLUDING REMARKS

No direct curative medical tinnitus treatments are available at this time. Some forms of treatment for chronic tinnitus are instrumental and cognitive behavioural methods which cannot heal tinnitus but teach individuals how to influence tinnitus cognition or perception. (see also Tyler, RS., 2006).

The burden of disease caused by community noise induced tinnitus had probably been so far largely underestimated. The data presented demonstrate that it is paramount medically, politically, and economically to implement effective preventive measures for noise pollution, particularly for the protection of minors and young adults.

3.8 PENDING ISSUES

The general formula for quantification of the burden of disease in terms of Disability Adjusted Life Year (DALY)s is:

DALY = YLL + YLD

where:
YLL = years of life lost due to premature mortality.
YLD = years lived with disability.

where YLL = N x L

where:
N = number of deaths.
L = standard life expectancy at age of death (in years).

and where
YLD = I x DW x L

where:

YLD	= years lived with disability.
I	= number of incident cases.
DW	= disability weight.
L	= average duration of disability (years)

According to current knowledge and the data presented, the authors consider that there are no YLL caused by community noise-induced tinnitus.

In terms of YLDs, the following methodological questions will have to be addressed :

- Prevalence measures available versus incidence measures used for YLDs; very few published articles have studied the incidence of tinnitus;
- NOAEL : a final consensus is necessary to estimate a valid NOAEL;

- Exposure per noise source : which noise sources are likely to cause tinnitus; for instance, should populations exposed to traffic noise >70 dB(A) be included? Do we have valid data for exposures to different leisure noises?
- ER-relationship and population attributable fraction: at this point, there is very scarce literature giving direct measures; the well-known occupational noise-NIHL relationship could be used under certain conditions;
- DW: the suggested DWs are a first proposal based on DWs for analogous conditions; a validation process by an expert panel or other valid approach should be performed;
- Cross-cultural issues: only expert opinions were available at the time this document was written; this issue will have to be addressed further.

ALPHABETICAL LIST OF CONSULTED REFERENCES

Adams, PF., Hendershot, GE., Marano, MA. (1999). Current estimates from the National Health Interview Survey, 1996. Vital Health Stat.10,(200): 1-203.

Babisch, W., Ising, H., Dziombowski, D. (1988) Einfluß von Diskothekbesuchen und Musikhörgewohnheiten auf die Hörfahigkeit bei Jugendlichen. Z Lärmbekämofung 35:1-9.

Begault, DR., Wenzel, EM., Tran, LL., Anderson, MR. (1998). Survey of commercial airline pilots' hearing loss. Percept.Mot.Skills, 86(1): 258.

Berglund, B., Lindvall, T., Schwela, DH. (eds) (2000). Guidelines for Community Noise. WHO, Geneva, 159p.

Biesinger, E., Heiden, C., Greimel, V., Lendle, T., Hoing, R., Albegger, K. (1998) Strategien in der ambulanten Behandlung des Tinnitus HNO 46: 157-169.

Cheesman, MF., Ciona, L., Mendoza, S., Grew, J. (2001) Participation Rates in Noisy Leisure Activities by Three Samples of Students. Canadian Acoustics 29(3):42-43.

Chung, DY., Gannon, RP., Mason, K. (1984). Factors affecting the prevalence of tinnitus. Audiology, 23(5): 441-452.

Coles, RRA. [1984] Epidemiology of Tinnitus Prevalence. Journal of Laryngology and Otology, 98, 7-15.

Concha-Barrientos, M., Campbell-Lendrum, D., Steenland, K. Occupational noise :assessing the burden of disease from work-related hearing impairment at national and local levels. Geneva, World Health Organization, 2004. (WHO Environmental Burden of Disease Series, No. 9).

Dauman, R., Tyler, RS. (1992). Some considerations on the classification of tinnitus. In. J. M. Aran, R. Dauman (Eds): Proceedings of the Fourth International Tinnitus Seminar, Bordeaux, France, pp. 225-229.

Dierhoff, HG. (1976) Soziakusis und Impulslärm. HNO-Praxis 4:494-499.

Dobie, RA. (2006) Foreword of Tyler RS. Tinnitus Treatment. Clinical Prococols. Thieme Medical Publishers inc. New York, 240p.

Eggermont, JJ., Roberts, LE. (2004). The neuroscience of Tinnitus. Trends in Neurosciences, 27(11):676-682.

Eggermont, JJ., (2005). Tinnitus: neurobiological substrates. Drug Discovery Today 10(19):1283-1290.

Fearn, RW. (1981) Hearing levels in school-children aged 9–12 years and 13–16 years associated with exposure to amplified pop music and other noisy activities. J Sound Vibration 74:151.

Fearn RW (1981) Serial audiometry in young people exposed to loud amplified pop music. J Sound Vibration 74:459–462.

Fearn, RW., Hanson, DR. (1984) Hearing level measurements of students aged 18–25 years exposed to amplified pop music. J Sound Vibration 94:591–595 #.

Girard, SA., Simard, M. (2005) Estimation du risque de développer un acouphène attribuable à une exposition extra-professionnelle chez des travailleurs otologiquement normaux. DSSS, Institut national de santé publique du Québec, unpublished preliminary data.

Goebel, G., Hiller, W. (1994). Tinnitus-Fragebogen (TF) : Standardinstrument zur Graduierung des Tinnitus-Schweregrades – Ergebnisse einer Multicenterstudie. HNO, 42, 166-172.

Graham, JM. (1987): Tinnitus in Hearing-impaired children. In: Hazell, J. (Hrsg.) Tinnitus. London: Churchill Livingstone.

Hallam, RS., Jakes, SC., Hinchcliffe, R. (1988) Cognitive variables in tinnitus annoyance. British Journal of Clinical Psychology, 27:213-222.

Hannaford, PC., Simpson, JA., Bisset, AF., Davis, A., McKerrow, W., Mills, R. (2005). The prevalence of ear, nose and throat problems in the community: results from a national cross-sectional postal survey in Scotland. Fam.Pract., 22(3): 227-233.

Hébert, S., Paiement, P., Lupien, SJ. (2004) A physiological correlate for the intolerance to both internal and external sounds. Hearing Research 4831:1-9.

Henry, JA., Meikle, M., Gilbert, A. (1999) Audiometric correlates of tinnitus pitch; Insights from the tinnitus data registry; in Hazell J (ed): Proceedings of the VIth International Seminar. Cambridge, The Tinnitus and Hyperacusis Center, pp 51-57.

Hill, AB. (1965) The Environment and Disease: Association or Causation? Proceedings of the Royal Society of Medicine, 58:295-300.

Holgers, KM. (2003) Tinnitus in 7-year-old children. Eur J Pediatr. 162(4):276-8.

Holgers, KM., Barrenäs, ML. (2003) The pathophysiology and assessment of tinnitus. In Textbook of Audiological Medecine –Clinical aspects of hearing and balance. Edited by Luxon, Linda and co-workers. Maison d'Édition MD Martin Dunitz, ch.32, 555-569.

Holt, EE. (1882). "Boiler-Maker's Deafness and Hearing in a Noise," Trans. Am. Otol. Soc. 3, 34-44. /2062/.

Ising, H., Babisch, W., (1998) Untersuchung der Hörfähigkeit und Musikhörgewohnheiten von Jugendlichen sowie der Akzeptanz eines pegelbegrenzten Kassettenabspielgeräts Z.f. *Audiologie Supplement* I, 195-201

Jastreboff, PJ. (1990) Phantom auditory perception (tinnitus): mechanisms of generation and perception. Neurosci Res. 8(4):221-54. Review.

Johansson, MS., Arlinger, SD. (2003) Prevalence of hearing impairment in a population in Sweden. Int J Audiol. 42(1):18-28.

Johnston, M., Walker, M. (1996). Suicide in the Elderly. Recognizing the signs. General Hospital Psychiatry 18:257-260.

Jokitulppo, J., Björk, E. (2002) Estimated Leisure-Time Exposure and Hearing Symptoms in a Finnish Urban Adult Population. Noise & Health 5(17):53-61.

Jones, JR., Hodgson, JT., Clegg, TA., Elliott, RC. (1998). Self-reported work-related illness in 1995. Results from a household survey. HSE Books. Health & Safety Executive, Government Statistical Services, Her Majesty's Stationery Office, Norwich, UK, 272 p.

Kentish, RC., Crocker, SR., McKenna, L. (2000) Children's experience of tinnitus: a preliminary survey of children presenting to a psychology department. Br J Audiol. 34(6):335-40.

Kuk, FK., Tyler, RS., Russell, D., Jordan, H. (1990) The Psychometric Properties of a Tinnitus Handicap Questionnaire. Ear and Hearing 11(6):434-442.

Llinas, R., Urbano, FJ., Leznik, E., Ramirez, RR., Van Marle, HJF. (2005). Rhythmic and dysrhythmic thalamocortical dynamics: GABA systems and the edge effect. Trends in Neurosciences, 28, 325-333.

Leroux, T. and Lalonde, M. (1993). Proposal for an enriched classification of abilities relating to the senses and perception - Hearing. International Classification of Impairments, Disabilities and Handicap (I.C.I.D.H) International Network, vol. 5 (3), vol. 6 (1), pp. 33-37.

Maassen, M., Babisch, W., Bachmann, KD., Ising, H., Lehnert, G., Plath, P., Plinkert, P., Rebentisch, E., Schuschke, G., Spreng, M., Stange, G., Struwe, V., Zenner, HP. (2001) Ear damage caused by leisure noise. Noise & Health 4(13):1-16.

MacFadden, D. (1982). Tinnitus Facts, Theories, and Treatments. Working Group 89. Committee on Hearing, Bioacoustics, and Biomechanics, National Research Council. Washington, DC: National Academy Press.

Mahlke, C. and E. Wallhausser-Franke (2004). "Evidence for tinnitus-related plasticity in the auditory and limbic system, demonstrated by arg3.1 and c-fos immunocytochemistry." Hear Res 195(1-2): 17-34.

Mathers, CD., Sabaté, E., Lopez, AD. (2001) Guidelines for epidemiological reviews: the Global Burden of Disease 2000 project. Revised 2001, Global Programme on Evidence for Health Policy, WHO, Geneva.

Mercier, V., Luy, D., Hohmann, B.W. (2003). The sound exposure of the audience at a music festival. Noise.Health, 5(19): 51-58.

Meric, C., Pham, E. et *al.* (1997). "[Translation and validation of the questionnaire "Tinnitus Handicap Questionnaire, 1990]." J Otolaryngol 26(3): 167-70.

Meric, C., Pham, E., & Chéry-Croze, S. (2000). Validation assessment of a French version of the tinnitus reaction questionnaire : A comparaison between data from English and French versions. *Journal of Speech, Language, and Hearing Research, 43*(1), 184-190.

Meyer-Bisch, C. (1996) Epidemiological evaluation of hearing damage related to strongly applied music (personal cassette players, discotheques, rock concerts) – High definition survey on 1364 subjects. Audiology 35:121-142.

Mrena, R., Savolainen, S., Kuokkanen, JT., Ylikoski, J. (2002) Characteristics of tinnitus induced by acute acoustic trauma: a long-term follow-up. Audiol Neurootol. Mar-Apr; 7(2):122-30.

Møller, AR. (2000) Hearing: Its physiology and pathophysiology. Academic Press, San Diego.

Newman, CW., Jacobson, GP., Spitzer, JB. (1996). Development of the Tinnitus Handicap Inventory. Arch Otolaryngol head neck surg. 122:143-148.

Nondahl, DM., Cruickshanks, KJ., Wiley, TL., Klein, R., Klein, BE., Tweed, TS. (2002). Prevalence and 5-year incidence of tinnitus among older adults: the epidemiology of hearing loss study. J Am Acad Audiol., 13(6): 323-331.

Norena, A., Micheyl C., Chéry-Croze, S., Collet, L. (2002) Psychoacoustic characterization of the tinnitus spectrum: Implications for the underlying mechanisms of tinnitus. Audiology and Neurootology, 7: 358-369.

Olsen Widén, SE., Erlandsson, SI. (2004a). Self-reported tinnitus and noise sensitivity among adolescents in Sweden. Noise.& Health, 7(25): 29-40.

Olsen Widén, SE., Erlandsson, SI. (2004b) The influence of socio-economic status on adolescent attitude to social noise and hearing protection. Noise & Health, 7(25):59-70.

Palmer, KT. et *al.* (2002). Occupational exposure to noise and the attributable burden of hearing difficulties in Great Britain. Occup Environ Med, 59:634-639.

Paré, L., Levasseur, M. (2000). «Problèmes auditifs et problèmes visuels» dans Enquête sociale et de santé 1998, 2e édition, Québec, Institut de la statistique du Québec, chapitre 14. accessible at

http://www.stat.gouv.qc.ca/publications/sante/pdf/e_soc98v2-6.pdf.

Parving, A., Hein, HO., Suadicani, P., Ostri, B., Gyntelberg, F. (1993). Epidemiology of hearing disorders. Some factors affecting hearing. The Copenhagen Male Study. Scand.Audiol., 22(2): 101-107.

Pilgramm, M., Rychlick, R., Lebisch, H., Siedentop, H., Goebel, G., Kirchhoff, D. (1999) HNO-Aktuell 7 (1999) 261-265).

Pilgramm, M., Rychlick, R., Lebisch, H., Siedentop, H., Goebel, G., Kirchhoff, D. (1999) Tinnitus in the Federal Republic of Germany: a representative epidemiological study. Proceedings of the Sixth International Tinnitus Seminar. Cambridge, UK, pp 64–67.

Plontke, SKR., Dietz, K., Pfeffer, C., Zenner, HP. (2002). The incidence of acoustic trauma due to New Year's firecrackers. Eur Arch Otorhinolaryngol 259:247-252.

Plontke, S., Schneiderbauer, H., Vonthein, R., Plinkert, PK., Lowenheim, H., Zenner, HP. (2003) [Recovery of normal auditory threshold after hearing damage from fireworks and signalling pistols] HNO. 51(3):245-50.

Plontke, S. and Zenner, HP. (2004a) Aktuelle Gesichtspunkte zu Hörschäden durch Berufs- und Freizeitlärm (in: Gesundheitsschäden durch Umwelt und Beruf, H.J. Schultz-Coulon, Ed.) Thieme Verlag, pp 122-164.

Puel, JL., Saffiedine, S., Gervais d'Aldin, C., Eybalin, M., Pujol, R. (1995) Synaptic regeneration and functional recovery after excitotoxic injury in the guinea pig cochlea. C R Acad Sci III. 318 (1). 67-75.

Puel, JL., Ruel, J., Gervais d'Aldin, C., Pujol, R. (1998) Excitotoxicity and repair of cochlear synapses after noise-trauma induced hearing loss. Neuroreport. 22; 9 (9): 2109-14.

Pujol, R., Puel, JL., Gervais d'Aldin, C., Eybalin, M. (1993) Pathophysiology of the glutamatergic synapses in the cochlea. Acta Otolaryngol. 113 (3): 330-4.

Pujol, R., Puel, JL. (1999) Excitotoxicity, synaptic repair, and functional recovery in the mammalian cochlea. A review of recent findings. Ann N Y Acad Sc. 28; 884: 249-52.

Roberts, J. (1968). Hearing status and ear examination. Findings among adults. United States-1960-1962. Vital Health Stat.11,(32): 1-28.

Robinson, DW., Lawton, DW., Rice, CG. (1994) Occupational Hearing loss from Low-level Noise. Institute of Sound and Vibration Research. University of Southampton, HSE Contract Research Report No. 68/1994.

Rosenhall, U. (2003). The influence of ageing on noise-induced hearing loss. Noise.Health, 5(20): 47-53.

Sanchez, L. et *al.* (1999). Prevalence and problems of tinnitus in the elderly. Proceedings of the the inmternational tinnitus seminar. Cambridge, UK, September 5th-9th, 1999.

Sataloff, J. (1952). Occupational Deafness, In Industrial Medicine and Surgery, The Journal of Medicine in Industry. Vol 21, No. 7, July, 1952.

Sindhusake, D., Golding, M., Wigney, D., Newall, P., Jakobsen, K., Mitchell, P. (2004). Factors predicting severity of tinnitus: a population-based assessment. J Am Acad Audiol., 15(4): 269-280.

Spoendlin, H. (1987) Inner ear pathology and tinnitus. In H. Feldmann (Ed.), Proceedings of the Third International Tinnitus Seminar (pp. 42-51). Munster: Harsch Verlag Karlsrehe.

Stephens, D., Hétu, R. (1991). Impairment, disability and handicap in Audiology: Towards a consensus. Audiology, 30:185-200.

Struwe, F., Jansen, G., Schwarze, S., Schwenzer, C., Nitzsche, M. (1996) Untersuchung von Hörgewohnheiten und möglichen Gehörrisiken durch Schalleinwirkungen in der Freizeit unter besonderer Berücksichtigung des Walkman®-Hörens. In: Babisch W, Bambach G, Ising H, Kruppa B, Plath P, Rebentisch E, Struwe F (Hrsg) Gehörgefährdung durch laute Musik und Freizeitlärm.WaBolu Hefte Umweltbundesamt 5:144–154.

Taylor, CF. (1976) Hearing loss in new apprentices due to exposure to non-industrial noise. J Soc Occup Med 26:57–58.

Tyler, RS., Baker, LJ. (1983) Difficulties experienced by tinnitus sufferers. Journal of Speech and Hearing Disorders 48:150-154.

Tyler, RS., ed. (2000). Tinnitus Handbook. South Africa. San Diego, Singular Thomson Learning 2000, 464p.

Tyler, RS. (2006) Tinnitus Treatment. Clinical Prococols. Thieme Medical Publishers inc. New York, 240p.

Unfallverhütungsvorschrift „Arbeitsmedizinische Vorsorge“ VBG 100, UVV Lärm, VBG 121, Stand Januar 1997. Heymanns, Köln.

Vernon, JA., Meikle, MB. (1988) Measurement of tinnitus: An update; in Kitahara M (ed): Tinnitus: Pathophysiology and Management. Todyo, Igaku-Shoin, pp36-52.

Vernon, JA., Møller, AR. (Eds.) (1995) Mechanisms of Tinnitus. Allyn and Bacon, Needham Heights, Ma, USA.

Vio, MM., Holme, RH. (2005). Hearing loss and tinnitus: 250 million people and a US$10 billion potential market. Drug Discovery Today 10(19):1263-1265.

Wallhäusser-Franke, E., Langner, G. (1999) Central activation patterns after experimental tinnitus induction in an animal model. In Proceedings of the Sixth International Tinnitus Seminar Cambridge, September 5-9, p.155-162.

Wallhausser-Franke, E., Mahlke, C., Oliv, R., Braun, S., Wenz, G., Langner, G. (2003). Expression of c-fos in auditory and non-auditory brain regions of the gerbil after manipulations that induce tinnitus. Exp Brain Res 153: 649-654.

West PDB, Evans EF (1990) Early detection of hearing damage in young listeners resulting from exposure to amplified music. Br J Audiol 24:89–103.

WHO (1997) Prevention of noise-induced hearing loss. Report of a WHO-PDH Informal Consultation, Geneva, 28-30 October 1997.

Williams, W., Purdy, S., Murray, N., LePage, E., Challinor, K. (2004). Hearing loss and perceptions of noise in the workplace among rural Australians. Aust.J Rural.Health, 12(3): 115-119.

Zenner, HP., Struwe, V., Schuschke, G., Spreng, M., Stange, G., Plath, P., Babisch, W., Rebentisch, E., Plinkert, P., Bachmann, KD., Ising, H., Lehnert, G. (1999a) [Hearing loss caused by leisure noise] HNO. 47(4):236-48. Review.

Zenner, HP. et *al.* (1999b) Noise from children's toys in dB(A); Results from randomly chosen German children's toys. European committee CEN/TC5L:"safety of toys".

Zenner, Puel, JL., Ruel, J., Guitton, M., Pujol, R. (2002) The inner hair cell afferent/efferent synapses revisited: a basis for new therapeutic strategies. Adv. Otorhinolaryngol. 59: 124-30.

Zenner, HP., Zalaman, IM. (2004) Cognitive tinnitus sensitization: behavioral and neurophysiological aspects of tinnitus centralization. Acta Otolaryngol. 124(4):436-9.

Zenner, HP., de Maddalena, H., Zalaman, IM. (2006): Validity and reliability of three tinnitus self-assessment scales: Acta Otolaryngo 125, 1184-1188.

Zhang, JS., Kaltenbach, JA. et *al.* (2003). "Fos-like immunoreactivity in auditory and nonauditory brain structures of hamsters previously exposed to intense sound." Exp Brain Res 153(4): 655-60.

ALPHABETICAL LIST OF COMPLEMENTARY REFERENCES

(1980) Teil 1: Einheitliche Ermittlung des Beurteilungspegels für Geräuschimmis-sionen. Teil 2: Einheitliche Ermittlung des Beurteilungspegels für Geräusch-immissionen. Mittelungspegel und Beur-teilungsvorgänge zeitlich schwankender Schallvorgänge. Beuth, Berlin

Arnold, W, Bartenstein, P, Oestreiche,r E, Römer, W., Schaiger, M. (1996) Focal Metabolic Activation in the predominant left Auditory Cortex in Patients suffering from tinnitus. ORL 58:195-199.

Axelsson, A., Jerson, T., Lindgren, F. (1981) Noisy leisure time activities in teenage children. Ind Hyg Assoc 42:229–233.

Axelsson, A., Lindgren, F. (1981) Pop music and hearing. Ear and Hearing 2:64–69.

Axelsson, A., Jersson, T. (1985) Noisy toys – a possible source of sensorineural hearing loss. Pedriatics 76:57.

Axelsson, A., Ringdahl, A. (1989) Tinnitus--a study of its prevalence and characteristics. Br.J Audiol., 23(1): 53-62.

Axelsson, A. (1996a) Recreational exposure of noise and its effects. Noise Control Eng J 44:127–134.

Axelsson, A. (1996b) The risk of sensorineural hearing loss from Noisy toys and recreational activities in children and teenagers. In: Prasker DK, Luxon LM (eds) First European Conference on Protection Against Noise. Bari, June 1996, pp58–65.

Axelsson, A., Prasher, D. (2000) Tinnitus induced by occupational and leisure noise. Noise and Health 8:47-54.

Babisch, W., Elke, JU., Goosens, C., Gruber, J., Ising, H., Winter, A. (1985) Beeinflussung der zweizeiligen Hörschwellenverschiebung durch psychologische Faktoren. Z Lärmbekämpfung 32:2–8.

Babisch, W., Ising, H. (1994) Musikhörgewohn-heiten bei Jugendlichen. Z Lärmbekämpfung 41:91–97.

Bambach, G., Ising, H. (1994) Schallpegel von Kinderspielzeugen. HNO 42:470–472.

Becher, S., Struwe, F., Schwenzer, C., Weber, K., Berger, R. (1931) Zur Geschichte der Lärm-bwehrbewegung. Schalltechnik 1:1–9.

BGA Pressedienst (1992) BGA warnt vor Gehörschäden durch Feuerwerkskörper und Spielzeugwaffen. BGA Pressdienst 61.

Bickerdike, J., Gregory, A. (1980) An evaluation of hearing damage risk to attenders at discotheques. Leeds Polytechnical School of Constructional Studies. Dept Environment Report.

Bogoch, II., House, RA., Kudla I. (2005) Perceptions about hearing protection and noise-induced hearing loss of attendees of rock concerts. Can J Public Health, 2005 Jan-Febr; 96(1):69-72.

Borchgrevink, HM. (1988) One third of 18 year old male conscripts show noise induced hearing loss >20 dB before start of military service. The incidence being doubled since 1981. Reflecting increased leisure noise? In: Berglund B, Berglund U, Karlsson J, Lindvall T (eds) Proceedings of the 5th International Congress On Noise As A Public Health Problem, Stockholm, vol 2. Council for Building Research, Stockholm, pp 27–32.

Borchgrevink, HM. (1993) Music-induced hearing loss >20 dB affects 30% of Norwe-gian 18 year old males before military service – The incidence doubled in the 80's, declining in the 90's. Noise and Man '93, Proceedings of the 5th International Congress On Noise As A Public Health Problem. Nice, vol 2, 25–28.Arcueil cedex: INRETS.

Budd, R.J., Pugh, R. (1996). Tinnitus coping style and its relationship to tinnitus severity and emotional distress. Journal of Psychosomatic Research, 41 (4), 327-335.).

Carter, NL., Waugh, RL., Keen, K., Murray, N., Bulteau, VG. (1982) Amplified music and young people's hearing. Med J Austr 2:125–128.

Chang, EF., Merzenich, MM. (2003) Environmental noise retards auditory cortical development. Science, 18 April 2003, Vol 300.

Ciona, LG., Cheesman, MF. (2000) Participation In Noisy Leisure Activities In A Sample of High School Students. Canadian Acoustics 28(3):148-149.

Clark, W. (1991) Noise exposure from leisure activities. A review. J Acoust Soc Am 90:175–181.

Davis, AC., Fortnum, HM., Coles, RRA., Haggard, MP., Lutman, ME. (1985) Damage to hearing arising from leisure noise: A review of the literature. Report prepared for the Health & Safety Executive by the MRC Institute of Hearing Research, Nottingham. ISBN 0118838172. London:Her Majesty's Stationery Office.

Davis, A. (1997) Hearing in Young adults – are those with high levels of leisure noise exposure different? Abstract of the Second European Conference, Protection Against Noise. April 1997, London.

Dey, FL. (1970) Auditory fatigue and predicted permanent hearing defects from rock and roll music. N Eng J Med 282:467–470.

Dieler, R., Sheata-Dieler, WE., Brownell, WE. (1991): Concomitant salicylate-induced alterations of outer hair cell subsurface cisternae and electromotility. J Neurocytol 20:637-653.

Dobie, RA. (2004) Overview: Suffering from Tinnitus. In: Tinnitus: Theory and Management. JS Snow (Ed). BC Decker Inc, Hamilton, London.

Eggermont, JJ. (1983): Tinnitus: some thoughts about its origin. J Laryng Otol□Suppl□ 9:31-37.

Ehrenberger, K., Felix, D. (1991): Glutamate receptors in afferent cochlear neurotrans-mission in guinea pigs. Hear Res 52:73-76.

Ehrenberger, K., Felix, D. (1995): Receptor pharmacological models for inner ear therapies with emphasis on glutamate receptors. Acta Otolaryngol 115:236-240.

Ehrenberger, K. (1997): Caroverine in tinnitus treatment - A placebo-controlled blind study. Acta Otolaryngol 117:825-830.

Evans, EF., Wilson, JP., Borerwe, TA. (1981): Animal models of tinnitus. In: Evans EF (ed): Tinnitus. (Ciba Foundation Symposium '85) Pitman, London, 108-148.

Feldmann, H. (1995): Mechanism of Tinnitus. In: Vernon JA, Möller A (eds): Mechanism of Tinnitus. Allyn and Bacon, Boston, 35-50.

Folmer, RL., Griest, SE. (2000). Tinnitus and Insomnia. American Journal of Otolaryngology, 21 (5). 287-293.

Halfortd, JBS., Stewart, D., Anderson, D. (1991). Tinnitus severity measured by a subjective scale, audiometry and clinical judgement. The Journal of Laryngology and Otology, 105 ;89-93.

Hanel, J. (1996) Schuljugend und laute Musik. Über die Bedeutung der technisch verstärkten Musik im Lebenskonzept von Schülerinnen und Schülern. Schriftenreihe des Vereins für Wasser-, Boden- und Lufthygiene, Bd 99. Fischer, Stuttgart.

Hazell, JWP. (1987): A cochlear model for tinnitus. In: Feldmann H (ed): Proceedings of the III International Tinnitus Seminar. Harsch, Karlsruhe, 121-130.

Hellel, HP. (1988) Effection hearing. Sound Vibration 127:262–264.

Hellström, PA., Axelsson, A. (1988) Sound levels habits and hazards of using port-able cassette players. J Sound Vibration 127:521–528.

Hellström, PA. (1991) The effects on hearing from portable cassette players. A follow-up study. J Sound Vibration 51:461–469.

Henry, JL., Kangas, M., Wilson, PH. (2001) Development of the Psychological Inpact of Tinnitus Interview : A Clinician-Administered Measure of Tinnitus-Related Distress. International Tinnitus Journal, 7 (1) ;20-26.).

Hoffmann, E. (1997) Hörfähigkeit und Hörschäden junger Erwachsener unter Berücksichtigung der Lärmbelastung. Median, Heidelberg.

Hoffman, HJ., Reed, GW. (2004) Epidemiology of Tinnitus. In: Tinnitus: Theory and Management. JS Snow (Ed). BC Decker Inc, Hamilton, London.

Holgers, K-M., Erlandsson, SI., Barrenäs, M-L. (2000). Predictive Factors for the Severity of Tinnitus. Audiology, 39 (5), 284-291.

HNO-Aktuell 7 (1999) 261-265.

Ising, H., Babisch, W., Gandert, J., Scheuermann, B. (1988) Hörschäden bei jugendlichen Berufsanfängern aufgrund von Freizeit-lärm und Musik. Z Lärmbekämpfung 35:35–41.

Ising, H., Rebentisch, E., Curio, I., Otten, H., Schulte, W. (1991) Gesundheitliche Wirkungen des Tieffluglärms Hauptstudie Forschungs-bericht 91-10501116. Umweltbundesamt, Berlin.

Ising, H. (1994) Gehörgefährdung durch laute Musik. HNO 42:465–466.

Ising, H., Babisch, W., Hanel, J., Kruppa, B., Pilgramm, M. (1994) Empirische Untersuchungen zu Musikhörgewohnheiten von Jugend-lichen. HNO 43:244–249.

Ising, H., Havel, J., Ailgramm, M., Babisch, W., Lindthammer, A. (1994) Gehörschadensrisiko durch Musikhören mit Kopfhörern. HNO 42:764–768.

Ising, H., Babisch, W., Kruppa, B. (1997) Loud music and hearing risk. Audiol Med 6:123–133.

Ising, H, Babisch, W., Neyen, S. (1999) Untersuchung der Hörfähigkeit und Musikhörgewohnheiten von Jugendlichen sowie der Akzeptanz eines pegelbegrenzten Kassettenabspielgeräts. (in Vorbereitung).

ISO 1999:1990 Acoustics – Determination of occupational noise exposure and estimation of noise-induced hearing impairment. International Organization for Standardization, Geneva, Switzerland.

ISO DIS 1999.2 (1985) Acoustics – Determination of occupational noise exposure and estimation of noise-induced hearing impairment. International Standardization Organization, Geneva.

Jansen, G., Schwarze, S. (1990) Lärmschäden. In: Konietzko J, Dupuis H (Hrsg) Handbuch der Arbeitsmedizin. Ecomed, Landsberg, S 1–8.

Jansen, G., Notbohm, G. (1994) Lärm. In:Wichmann HE, Schlipköter HW, Fülgraff G (Hrsg) Handbuch der Umweltmedizin. Ecomed, Landsberg, S 1–22.

Jastreboff, PJ., Hazell, JW. (1993) A neurophysiological approach to tinnitus: clinical implications. Br J Audiol. 1993 Feb;27(1):7-17. Review.

Jastreboff, P. (1995): Tinnitus as a phantom perception: Theories and clinical implications. In: Vernon JA, Möller AR (eds): Mechanism of Tinnitus. Allyn and Bacon, Boston, 73-87.

Jastreboff, PJ. (2004) The neurophysiological model of tinnitus. Tinnitus: Theory and Management. JS Snow (Ed). BC Decker Inc, Hamilton, London.

Jerger J, Jerger S (1970) Temporary threshold shift in rock-and-roll musicians. J Speech Hear Ass 13:218–224.

Kaharit, K., Zachau, G., Eklof, M., Sandsjo, L., Møller, C. (2003) Assessment of hearing and hearing disorders in rock/jazz musicians. Int J Audiol 2003 Jul, 42(5):279-88.

Kemp, DT. (1981): Physiologically active cochlear micromechanics: one source of tinnitus. In: Evans EF (ed): Tinnitus. (Ciba Foundation Symposium ’85) Pitman, London, 54-81.

Körpert, K. (1992) Hearing thresholds of young workers measured in the period from 1976 to 1991. Swiss Acoust Soc 181–184.

Kruppa, B., Dierhoff, HG., Ising, H. (1995) Sensori-neurale Gehörschäden bei Schulanfängern. HNO 43:31–34.

Laitinen, H. (2005) Factors affecting the use of hearing protectors among classical music players. Noise and Health, Vol 7, Jan-Mar 2005, pp. 21-29(9).

Lercher, P. (1996) Environmental noise and health: an integrated research perspective. Environmental International, Volume 22, Number 1, 1996, pp. 117-129(13).

Lutman, ME. (1985) Damage to hearing arising from leisure noise: A review of the literature. Report prepared for the Health & Safety Executive by the MRC Institute of Hearing Research, Nottingham. ISBN 0118838172. London: Her Majesty’s Stationary Office.

Lenarz, Th., Schreiner, Ch., Snyder, RL., Ernst, A. (1995): Neural Mechanism of Tinnitus: The pathological ensemble spontaneous activity of the auditory System. In: Vernon JA, Möller AR (eds): Mechanism of Tinnitus. Allyn and Bacon, Boston, 101-111.

Lindemann, HE., Klaauw, MM. vd, Platenburg-Gits, FA. (1987) Hearing acuity in male adolescents (young adults at the age 17–23 years). Audiology 26:65–78.

McKenna, L., Andersson, G. (2003) Psychological aspects of hearing impairment and tinnitus. In Textbook of Audiological Medecine –Clinical aspects of hearing and balance. Edited by Luxon, Linda and co-workers. Maison d'Édition MD Martin Dunitz, ch. 35, 593-601.

McKenna, L. (2004) Models of tinnitus suffering and treatment compared and contrasted. Audiological Medicine, Vol 2, Nr. 1/Msrch 2004, pp 41-53. Royal National throat Nose and Ear Hospitable London. Taylor and Fancis.

Meecham, EA., Hume, KI. (2001) Tinnitus, attendance at night-clubs and social drug taking in students. Noise & Health 3(10):53-62.

Mercier V, Würsch P, Hohmann B (1998) Hörgefährdung Jugendlicher durch überlauten Musikkonsum. Z Lärmbekämpfung 45:17-21.

Meyen, S. (1997) Ergebnisse einer Berliner Studie zu Musikexposition und Hörfähig-keit bei Schülern. Referat bei der 9. Sitzung der UBA-Kommission "Soziakusis (Zivilisations-Gehörschäden)".

Møller, AR. (2003) Pathophysiology of tinnitus. Otolaryngol Clin North Am. 2003 Apr;36(2):249-66, v-vi. Review.

Mori, T. (1985) Effects of record music on hearing loss among young workers in a shipyard. Int Arch Occup Environ Health 56:91–97.

Neitzel, R., Seixas, N., Olson, J., Daniell, W., Goldman, B. (2004) Nonoccupational noise:exposures associated with routine activities. J. Accoust. Soc. Am. 115(1):237-. [to be completed].

Oesterreicher, E., Arnold, W., Ehrenberger, K., Felix, D. (1998): Memantine suppresses the glutamatergic neurotransmission of mammalian inner hair cells. ORL Nova 60(1):18-21.

Passchier-Vermeer, W. (1968) Hearing loss due to exposure to steady-state broad-band noise. Institut voor Gezondheitstechniek, Sound & Light Division 35.

Plath, F. (1994) Schwerhörigkeit durch Freizeitlärm. HNO 42:483–487.

Plath, F. (1995) Gesundheitsgefahren durch Lärm. Wissenschaft und Umwelt 2:35–98.

Plinkert, PK., Gitter, AH., Zenner, HP. (1990): Tinnitus-associated spontaneous otoacoustic emissions: active outer hair cell movements as a common origin? Acta Otolaryngol (Stockh) 110:342-347.

Plontke, S. and Zenner, HP. (2004b) Current Aspects of Hearing Loss from Occupational and Leisure noise. In Schultz-Coulon HJ (ed.) Environmental Occupational Health Disorders. Videel, Niebuell, Germany, 233-325.

Prasher, D., Axelsson, A. (2000) Tinnitus induced by occupational and leisure noise. *Noise and Health*, Vol 2, Nr. 8, Jul-Sept 2000, pp.47-54(8).

Preyer, S., Bootz, F. (1995): Tinnitusmodelle zur Verwendung bei der Tinnituscounselling-therapie des chronischen Tinnitus. HNO 43:338-351.

Price, GR. (1979) Loss of auditory sensitivity following exposure to spectrally narrow impulses. J Acoust Soc Am 66:456–464.

Richter, U. (1990) Wird eine Zulassungs-prüfung von Mini-Kassettengeräten („Walkman®) notwendig? Strahlensch Aktuel 6:25–26.

Rice, CG., Rossi, G., Olina, M. (1987) Damage risk criteria from personal cassette players. Br J Audiol 21:279–288.

Rintelmann, WF., Lindberg, RF., Smithley, EK. (1971) Temporary threshold shift and recovery patterns from two types of rock-and-roll music presentations. Acoust Soc Am 51:1249–1255.

Rosenhall, U., Axelsson, A., Svedberg, A. (1993) Hearing in 18-year old men – is high frequency hearing loss more common today than 17 years ago? Proc of the 6th Intern Congress on Noise as a Public Health Problem, 1993.Actes INCRETS No 34, vol 2, pp 119–122.

Rudloff, F., Specht, H. von, Penk, J., Schuschke, G. (1996) Untersuchungen zu Ausmaß und möglichen Folgen jugendlichen Musikkonsums. Teil 3: Ergebnisse von Schall-pegelmessungen und audiologischen Untersuchungen. Z Lärmbekämpfung 43:9–14.

Rupp, RR., Koch, LJ. (1969) Effects of too loud music on human ears.„But, mother, rock'n roll has to be loud!" Clin Pediatr 8:60–62.

Sadlier, M., Stephens, SDG. (1995). An approch to the audit of tinnitus management. The journal of Laryngology and Otology., 109:826-829.

Schriftenreihe der Bundesanstalt für Arbeitsschutz; FB 630; Wirtschaftsverlag NW, Bremerhaven.

Schuschke, G., Rudloff, F., Grasse, S., Tanis, E. (1994) Untersuchungen zu Ausmaß und mögli-chen Folgen jugendlichen Musikkonsums. Teil 1: Ergebnisse der Befragung. Z Lärmbekämpfung 41:121–128.

Shulman, A., Goldstein, B. (1996): A final common pathway for tinnitus. Intl Tinnitus J 2:137-142.

Smith, PA., Davis, A., Ferguson, M., Lutman, ME. (2000): The prevalence and type of social noise exposure in young adults in England. Noise & Health 6:41-56.

Smoorenburq, GF. (1993) Risk of noise – induced hearing loss following exposure to Chinese firecrackers. Review paper. Audiology 32:333–343.

Snow, JB. (2004) Tinnitus: Theory and Management. BC Decker Inc. Hamilton London.

Spreng, M., Leupold, S., Firsching, S. (1991) Gehörschäden durch Impulslärm – Vorschlag für ein gehörschadensrichtiges Impulsbewertungssystem.

Stach, BA. (1997) Comprehensive Dictionary of Audiology. Williams, Wilkins. Baltimore, Maryland, USA.

Struwe, F., Jansen, G., Schwarze, S., Schwenzer, C., Nitzsche, M., Notbohm, G. (1995) Hearing loss induced by leisure noise: subjective evaluation and audiometric assessment. In: Newman M (ed) Proceedings of the 15th International Congress on Acoustics Trondheim 1995, vol 2, pp 303–305.

Tyler, RS. (1993) Tinnitus Disability and Handicap Questionnaires. Seminars in Hearing 14(4):377-384.

Unfallverhütungsvorschrift „Lärm“ VBG 121, vom 1. Juni 1990. Fassung Januar 1997. Heymanns, Köln.

VDI 2058, Blatt 2 (1988) Beurteilung von Lärm hinsichtlich Gehörschäden. Verein Deutscher Ingenieure, Düsseldorf.

VDI 2058, Blatt 2, VDI 2055 Blatt 2 (1988) Beurteilung von Lärm hinsichtlich Gehörschäden. Verein Deutscher Ingenieure, Düsseldorf.

WHO-fact sheet N˚258 revised February 2001. http://www.who.int/mediacentre/factsheets/fs258/en/print.html.

Williams, W. (2005) Noise exposure levels from personal stereo use. International Journal of Audiology 44:231-236.

Wilson, PH., Henry, JL., Bowen, M., Haralambous, G. (1991) Tinnitus Reaction Questionnaire: Psychometric properties of a measure of distress associated with tinnitus. Journal of Speech and Hearing Research 34:197-201.

Wilson, PH., Henry, JL. (1998). Tinnitus Cognitions Questionnaire: Development and Psychometric properties of a measure of dysfunctional cognitions associated with tinnitus. International Tinnitus Journal 4:23-30.

Zeigler, MC., Taylor, JA. (2001) The effects of tinnitus awareness survey on college music majors’ hearing conservation behaviours. Medical Problems of Performing Artists: Vol 16, Nr. 4, p. 136.

Zenner, HP. (1987): Modern aspects of hair cell biochemistry, motility and tinnitus. In: Feldmann H (ed): Proceedings of the III International Tinnitus Seminar. Harsch, Karlsruhe, 52-57.

Zenner, HP., Gitter, AH. (1987): Possible roles of hair cell potential and ionic channels in cochlear tinnitus. In: Feldmann H (ed): Proceedings of the III International Tinnitus Seminar. Harsch, Karlsruhe, 306-310.

Zenner, HP., Ernst, A. (1993): Cochlear-motor, transduction and signal-transfer tinnitus. Eur Arch Otorhinolaryngol 249:447-454.

Zenner, HP. (1994) Hören. Thieme, Stuttgart New York.

Zenner, HP., Ernst, A. (1995): Three models of cochlea tinnitus. In: Vernon JA, Möller AR (eds): Mechanism of Tinnitus. Allyn and Bacon, Boston, 237-252.

Zenner, HP. (1998) A Systematic Classification of Tinnitus Generator Mechanisms. Int Tinnitus J. 4(2):109-113.