

PREVENTION OF NOISE-INDUCED HEARING LOSS

**REPORT OF AN
INFORMAL CONSULTATION**

**held at
the World Health Organization, Geneva
on
28-30 October 1997**

**Number Three in the series:
*“Strategies for Prevention of Deafness and Hearing
Impairment”***

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KEY POINTS FROM THE CONSULTATION

- Exposure to excessive noise is the **major avoidable cause** of permanent hearing impairment worldwide.
- Noise-induced hearing loss is an **important public health priority** because, as populations live longer and industrialization spreads, NIHL will add substantially to the global burden of disability.
- In a developed country, excessive noise is at least partially the **cause in more than one-third** of those with hearing impairment.
- In many countries, excessive noise is the **biggest compensatable occupational hazard**.
- The estimated **costs of noise** to developed countries range from 0.2% to 2% of GDP (gross domestic product).
- In developed countries, the **risk from social noise is increasing** for young people.
- In developing countries, **occupational noise and urban, environmental noise** (especially traffic noise) are increasing risk factors for hearing impairment.
- Developing countries often **lack both effective legislation against noise and programmes** to prevent noise-induced hearing loss. Where these exist, they are often poorly enforced and implemented.
- There is a serious **shortage of accurate epidemiological information** on prevalence, risk factors and costs of NIHL, especially in developing countries.
- **National Programmes for prevention of noise-induced hearing loss should be established** or strengthened in all countries and integrated with Primary Health Care (PHC). Elements should include environmental and medical surveillance, noise reduction, effective legislation, inspection, enforcement, health promotion and education, hearing conservation and compensation, and training.
- **Prevention** of noise-induced hearing loss must be appropriate (i.e. it makes sense), adequate (it makes a difference), acceptable (one can live with it), and affordable (to the individual and community)
- Because there is widespread ignorance of the hazard, **awareness must be increased** about the harmful effects of noise on hearing and about the prevention and control of noise-induced hearing loss. A positive image of hearing should be promoted, including its contribution to the daily quality of life.
- **Research needs to be undertaken** on pathogenic mechanisms, technical measures for noise abatement, improving hearing protectors, and low cost medications for prevention.
- **Communication and collaboration should be strengthened** between developed and developing countries to facilitate research and development in this field

SUMMARY

(1) PURPOSE OF THE MEETING:

A **consultation** of experts on the prevention of deafness and hearing impairment from noise-induced hearing loss (NIHL) was convened by WHO in October 1997. Its task was to review the epidemiology, pathogenesis and prevention of NIHL, and to draw up recommendations for future action to address the problem in the context of Primary Health Care, especially in developing countries.

(2) THE PROBLEM:-

Exposure to excessive noise is the **major avoidable cause of permanent hearing impairment** worldwide. In a developed country, it is at least partially the cause in more than one-third of those with hearing impairment and, in many countries, is the biggest compensatable occupational hazard. As the risk from occupational noise begins to decrease in developed countries, that from social noise is increasing for young people. In developing countries, occupational noise and urban, environmental noise are increasing risk factors for hearing impairment. As populations live longer and industrialization spreads, NIHL will add substantially to the global burden of disability, and hence has a **high public health priority**.

Excessive sound damages the hair cells and the blood supply in the cochlea, initially at a frequency around 4 kHz. The threshold shift is temporary at first but with a higher sound dose becomes permanent. Hair cells transducing the higher frequencies are the most sensitive to noise damage; this relates to difficulties with speech perception experienced by those with NIHL. Hearing losses from different causes are additive and interaction can occur between noise exposure and chemicals such as toluene, or antibiotics such as the aminoglycosides. In the elderly, NIHL may add to the hearing loss of presbycusis to produce a hearing handicap sooner and worse than would occur from age alone.

(3) REPORTS FROM THE WHO REGIONS OF THE WORLD:-

There is widespread and increasing excessive noise exposure everywhere, especially in developing countries. In **Africa** there are high noise exposure levels in the formal (eg manufacturing, mining) and informal occupational sector (small industries such as vehicle repairing, metal-working, milling), as well as the non-occupational sector (urban, environmental and leisure). Awareness of hazard amongst employers, employees and the public is low. Most countries in the region do not have effective programmes for prevention of NIHL.

In **North America** recent studies of environmental noise have shown that children may receive more noise at school than workers from an 8-hour work day at a factory and that regular attendees at professional sporting events are exposed to levels and durations that exceed most federal guidelines. The US National Institute for Occupational Safety and Health (NIOSH) in 1998 recommended an 85 dBA recommended exposure level (REL) with a 3 dB exchange rate, defined a hearing loss prevention programme, redefined the significant threshold shift and derated the hearing protector noise reduction ratings. Some Canadian provinces use similar recommendations. In **Latin America** there have been problems assessing the magnitude of the problem, (which is thought to be large), with poor enforcement of legislation and poorly implemented hearing conservation programmes. Recently improvements have occurred in legislation and enforcement and increased worker participation.

Noise is an important cause of environmental pollution in countries in the **Eastern Mediterranean**, especially in urban centres. Industry (eg textile factories, forge-hammering plants), traffic noise, and leisure noise are important sources and in many cases give rise to

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significant NIHL. Legislation is available but seldom enforced; compensation may be difficult to obtain.

In **Europe**, directives to industry have improved noise emission levels over the last two decades and reduced the risk of damage to hearing by providing hearing protection for workers. However, improvements in industrial noise have been offset by increasing environmental noise including that from traffic and recreational activities, especially amongst young people. The estimated costs of noise to society, especially transport noise, range from 0.2% to 2% of GDP.

Countries in **South-East Asia** generally have NIHL prevention programmes and legislation, but these are often poorly implemented and enforced and workers are ignorant of the problem. A study in one country in the region demonstrated between one-fifth and one-third of workers in certain occupations have NIHL.

In **Japan** numerous studies have been conducted on noise control and hearing conservation. Administrative guidelines have recently been issued for prevention of NIHL in workplaces where the noise level as measured by $L_{Aeq,8h}$ is not less than 85 dB. Pure-tone audiometry is performed at recruitment and relocation, and in principle every six months. Education and training is given for workers and supervisors. Noise-induced hearing loss is seen largely in the manufacturing industry, particularly shipbuilding, where most compensation has been paid.

(4) DEFINITION

The consultation **defined noise-induced hearing loss**, for survey purposes only, according to (1) Noise exposure history: 100 dB (NI) or 83 dBA $L_{Aeq,40}$ for a 50 year lifetime (equivalent exposure), (2) Audiometric criteria: sensorineural but not unilateral, 0.5 kHz threshold less than 50 dBHL, and at least a 15 dB difference between high and low frequency threshold averages in under 50 year-olds.

(5) WHAT NEEDS TO BE DONE?

There is a serious shortage of accurate **epidemiological information** relating to NIHL, especially in developing countries. Priorities to address this should include synthesis of existing data, new prevalence and longitudinal surveys of significant noise exposure and NIHL, the development of effective screening methods to enable early identification of and intervention against NIHL, and studies to determine the social and economic consequences of NIHL.

National Programmes should be established or strengthened in all countries and integrated with Primary Health Care (PHC). They should address general educational needs and particular risk situations. However developing countries face severe constraints in their ability to deal with the problem of NIHL. Consequently, collaboration with concerned NGOs and other interested parties should be fostered to support prevention at the community level.

There is a great **need for increasing awareness** about the harmful effects of noise on hearing and about the prevention and control of NIHL, including hearing conservation and legislation. Key messages on these topics should be widely disseminated by multiple methods in a coordinated programme, to the general public, to schools, for health education, and to PHC workers, for advocacy in the local community. A positive image of hearing should be promoted, including its contribution to the daily quality of life. However, it is recognised that, at present, our knowledge of the best ways to influence attitudes about noise and recreational habits is quite poor. This might be done through specially trained "noise educators".

Occupational Noise is still a major problem particularly in developing countries. Some countries do not have effective legislation or programmes to deal with it. Legislation should be introduced in all countries together with an effective inspectorate. The noise source should be

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reduced where possible and hearing conservation programmes, including audiometry and workers' education and protection, should be introduced. Personnel may need to be trained to carry out noise surveys and audiometric testing. Workers compensation schemes are also needed and these must be fair and workable. The costs of prevention through noise reduction may be high but so also are the costs of compensation.

Detection and monitoring for occupational noise should include environmental and medical surveillance. Different approaches to this may be seen: the compliance approach sees regulations as standards to be achieved and focuses on monitoring of the hazard and of exposed workers but reacts only when certain levels are exceeded; the prevention approach sees regulations as minimum standards, involves the workforce in establishing the programme, monitors all employees, and utilises customised intervention strategies.

Rapid urbanization in many developing countries is resulting in **traffic noise** in cities at levels which are likely to cause hearing impairment. Traffic noise needs to be reduced by, for example, devising and enforcing regulations, promoting proper use of silencers, effective land use planning, and using quieter technology.

Firearms are a proven source of noise-induced hearing impairment and people who fire a weapon (professionally or at leisure) should be made aware of the danger to themselves and others, and of the need for proper ear protection. Other **leisure pursuits** may be damaging sources of noise to adults and children. These pursuits should be limited, and hazardous items (including children's toys) marked as sound safe.

As well as the needed epidemiological data described above, **Research** needs to be undertaken on pathogenic mechanisms including risk factors, individual susceptibility and interaction of other toxic agents with noise. Research on prevention should include engineering research on technical measures for noise abatement and improving hearing protectors, and low cost medications for prevention.

To facilitate more basic and applied research, effective networking should be developed for **communication and collaboration** between interested institutions in developed and developing countries, as well as twinning of institutions, exchange of faculty personnel, and joint research projects.

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1 INTRODUCTION

The World Health Organization's Programme for the Prevention of Deafness and Hearing Impairment is concerned with developing and promoting strategies for prevention of the major causes of hearing impairment and deafness which constitute public health problems. The strategies should be global in scope but should be especially applicable to developing countries, where most work of WHO is focused.

The Programme has already addressed strategies for prevention of deafness and hearing impairment from ototoxic drugs and from chronic otitis media. It was appropriate that this meeting should be convened to address noise-induced hearing loss, another major cause, since this condition should be particularly amenable to prevention. Other WHO Programmes have convened meetings to address the problem of noise in the occupational and community settings but this was the first to be concerned solely with noise-induced hearing loss.

This informal consultation on the prevention of noise-induced hearing loss was held at the World Health Organization on the 28th to 30th October 1997 and was attended by 30 participants from 13 countries. Professor S Soliman, Dr G Bock, and Professor V Newton were unanimously elected chairman, vice-chairman and rapporteur respectively.

The **agenda** was adopted without modification and is included in Annex 1; the list of participants is in Annex 2.

The **scope of the meeting** was to address the problem of noise-induced hearing loss as a significant cause of hearing impairment in all countries of the world, but especially in developing countries. It focussed on excessive social noise but also reviewed the effects of excessive occupational and environmental noise. The role of noise-induced hearing loss as a public health problem, and the possibilities for preventing hearing impairment by controlling excessive noise in the context of primary health care were considered.

The **purposes** of this meeting were as follows:-

First, (agenda items 2-4), it **reviewed current knowledge** and opinion on the pathogenesis and epidemiology of noise-induced hearing loss. Some indication of the size of the problem worldwide was also given by reports from the six WHO regions of the world, focusing particularly, but not exclusively, on the situation in various developing countries.

Second, (agenda item 5) the **methods available for prevention and management** of noise-induced hearing loss were examined from the individual, environmental and occupational standpoints. The effectiveness of these methods, including cost effectiveness, were addressed as well as their appropriateness for implementation in developing countries and integration into primary health care. The issue of detection and monitoring was covered in this section.

Third, (agenda item 6), the participants looked at the elements necessary for the **development of a national plan for the prevention of noise-induced hearing loss**, using examples from two developing countries and one developed country. This item was intended to address the particular needs and constraints in developing countries, such as the lack of resources for providing individual rehabilitation, or for enforcing legislation or implementing hearing conservation programmes.

Fourth, (agenda item 7), the meeting determined the principal **immediate and longer-term needs** in this field, especially with regard to data collection and research opportunities.

Fifth, and most important, (agenda item 8), the meeting made **recommendations for future action**. These recommendations can be utilised in different ways. They include specific recommendations for ways of preventing, controlling and managing noise-induced hearing loss. They can be utilised by governments or other organisations for the setting up and implementing of national programmes. They can be recommendations for future research or other activities. They can be actions by WHO or other bodies. It is hoped that these recommendations take into

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account what is most appropriate and cost-effective, particularly for developing countries, and how activities proposed can be integrated within primary health care.

The **outcomes** of the meeting were to raise awareness amongst WHO member states of the size and nature of the problem of noise-induced hearing loss and the most appropriate and effective measures for its prevention. The recommendations will provide a framework for the development by the Programme for the Prevention of Deafness and Hearing Impairment of model guidelines for prevention of noise-induced hearing loss. These guidelines can then be adapted and customised by the various regions and by countries for incorporation into their national health programmes.

The **product** of the meeting is this report which contains the key points of each of the presentations and the ensuing discussions, and recommendations. The report will be disseminated to all participants, to other interested organisations and institutions, and to WHO Regional Offices and to member states. The executive summary gives the main points of the meeting. Copies of the full texts of the original working papers may be obtained from Prevention of Deafness and Hearing Impairment (PDH), World Health Organization, 1211 Geneva 27, Switzerland.

2 PATHOGENESIS OF NOISE-INDUCED HEARING LOSS

Excessive sound levels produce a hostile acoustic environment by masking wanted signals (eg speech or warning signals), and, with chronic exposure, by a central blocking-out of all auditory signals. In addition they damage the cochlea and thus produce noise-induced hearing loss. All these have a deleterious effect on education, communication, and the hearing of warning signals.

Hearing losses from many causes are additive, so that noise-induced hearing loss has become a major cause of handicap in the ageing population, producing handicap sooner than would occur from age alone. There is also interaction between noise exposure and inhaled organic solvents such as toluene and certain ototoxic drugs such as cisplatin and aminoglycoside antibiotics.

Sound damages the ear first at a frequency of about 4 kHz (the "4 kHz notch") and one of the reasons for this is the acoustic resonance characteristics of the external ear. This hard-walled tube, closed at one end, amplifies acoustic energy in the upper frequencies by about 10 decibels. In addition, individual variation in the acoustic transfer characteristics of the tube is a factor in the large variability in people's susceptibility to noise.

Transduction of sound vibration to nerve impulses occurs in the cochlea. The hair cells in the organ of Corti may be damaged directly by noise, or indirectly by very high levels of continuous sound which causes vasoconstriction of the vessels of the stria vascularis in the cochlea blood supply. This renders the hair cells relatively anoxic and thus secondarily damaged.

The amount and type of direct hair cell damage depends on the intensity of the sound. Above a certain minimum of frequency and intensity, the outer hair cells show signs of metabolic exhaustion with drooping of the stereocilia. This correlates with the common phenomenon of temporary threshold shift (TTS), which recovers within a few hours. Higher sound levels damage the outer hair cell stereocilia further, including destruction of the inter-cilial bridges, and recovery takes longer. Even higher levels of sound lead to collapse of the stereocilia, and the hair cell is eventually phagocytosed.

Outer hair cells amplify the movement of the basilar membrane of the cochlea by contracting when stimulated by sound. This increases the stimulus delivered to the inner hair cells which transduce the mechanical movement to trigger a nervous impulse in the afferent nerve endings of the 8th nerve. If the outer hair cells are not functioning, greater stimulation is required to initiate a nervous impulse; thus the threshold sensitivity of the inner hair cells is raised which is perceived as a hearing loss. Hair cells in the basal coil of the cochlea are the most sensitive to noise damage; they are responsible for transducing higher frequencies and this accounts for the high frequency hearing loss found in noise-damaged ears.

3 EPIDEMIOLOGY OF NOISE-INDUCED HEARING LOSS

Noise exposure is the commonest preventable cause of sensorineural hearing loss. It is as great a problem in developing as in developed countries, and as populations live longer and industrialization spreads, it will add substantially to the global burden of disability.

There is a great lack of good quality data describing the epidemiology of acquired adult sensorineural hearing impairment worldwide. A literature search for 1990 - 1997 produced no published work that would enable accurate comparisons to be made amongst and within countries concerning the epidemiology of hearing impairment and the contribution of environmental noise (including occupational and social sources eg aircraft, traffic, music etc). However some generalisations can be made (see Box 1 and footnote¹).

- noise continues to be the largest compensatable occupational hazard
- occupational noise exposure is a decreasing hazard, but still substantial
- social noise is increasing as a hazard for young people as occupational noise decreases

In less developed countries:-

- environmental noise is an increasing hazard, particularly traffic in urban areas
- occupational noise is probably a huge hazard, but the scale of the problem and its effects needs much further systematic high quality research on long-term damage

¹ The term "more developed" in box 1 includes the UN categories of "developed market economies" (ie all the "western" industrialised countries) and "economies in transition" (Eastern European countries and newly independent former Soviet Socialist Republics); the term "less developed" in box 1 includes the UN categories of "developing countries" and "least developed countries". For further information see The World Health Report 1997, [WHO, Geneva 1997], Annex 2 pages 139-140.

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The UK National Study of Hearing (NSH) was conducted in the 1980s in the UK, and has been useful in calculating national prevalence for hearing impairment and tinnitus and in estimating the contribution of demographic factors to prevalence and distribution of hearing impairment². A similar national study has been conducted in Italy obtaining almost identical results³. Data from such studies are useful in establishing the overall prevalence of hearing impairment and assessing the severity/age/sex distributions of hearing impairment and the impact of environmental factors on hearing impairment at particular ages and in particular occupations.

²Davis, 1995; *Hearing in Adults*, Whurr, London

³Quaranta, Asennato, Sallustio, 1996; *Scand Aud Suppl* 25 (42) 9-13

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Such studies may also be used to estimate the prevalence in other countries where the age and sex distribution are known and where the factors that influence the prevalence of hearing impairment may be thought to be similar. This has worked well in some countries (eg Denmark, Australia, Sweden) where this approach is now well validated. In other countries the socioeconomic groupings and the risks from middle ear disease and from occupational hazards may be very much different. However, in the absence of high quality data the NSH has been used to give the lower limits of the prevalence of hearing impairment in other countries and areas given a particular age and sex distribution. For the whole world this produces a low-bound estimate of almost 441 million people with a hearing impairment of at least 25 dB HL in their better hearing ear (over the mid frequencies 0.5, 1, 2 and 4 kHz). This estimate decreases to about 127 million for at least 45 dB HL, with more women than men being thus impaired, and 39 million for at least 65 dB. The sex difference is due to the higher age expectancy for women in 'more developed regions'; in 'less developed regions' the overall difference is reversed and there are more men than women with hearing impairments. (China was omitted because of uncertainty over the age/sex distribution.) The proportion of hearing-impaired people who are aged under 50 years is greater in less developed regions than in more developed regions.⁴

Data from the NSH show that the distribution between manual and non-manual subjects is about equal (48% and 52% respectively). The manual, male workers have a prevalence of hearing impairment that is greater than the non-manual, male workers (23 vs 15%, for ≥ 25 dB HL). Overall about a third of the hearing impaired had a history of occupational noise exposure (≥ 80 dBA Leq⁵ for a 50 year working lifetime equivalent), but for the male-manuals there were 60% who had had such noise exposure. Less developed countries may have a greater percentage of the population who are in manual occupations and a higher proportion of these may be involved in noisy

occupations. Both of these factors would increase the prevalence and absolute numbers of people with hearing impairments in less developed countries. The real numbers of hearing impaired in the less developed countries may be an order of magnitude greater than has been calculated from the NSH data if there is [a] a higher prevalence of childhood ear disease (due mainly to otitis media and other infectious causes), [b] if there is a greater proportion of 'manual' workers and [c] if there is a higher proportion exposed to ≥ 90 dBA Leq 40 for a 50 yr working lifetime equivalent (80-89 dBA does not give very clear or substantial impairments in most cases). If it is assumed that in the developing regions there are far fewer non-manual jobs, but

● A synthesis of all the published and unpublished data concerning the epidemiology of hearing

● A systematic survey of the extent of occupational and non-occupational noise exposure in less developed regions, including measures taken to control the problem

● Surveys to assess hearing impairment/disability in various noise environments

● Surveys of noise levels in different environments (eg workplace, home, traffic, social venues).

● Representative surveys of the prevalence of significant hearing impairment in less developed regions (including assessing the component due to noise and rehabilitative efforts)

● Economic modelling of the effect of hearing impairment on economies to illustrate the effect of introducing prevention, education and rehabilitation.

⁴ A table of these calculations for all countries can be found in Professor Davis's working paper.

⁵ Leq is defined as that continuous noise level (dBA) which, over a specified period of time, would have the same acoustic energy as a succession of discrete noise events

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that the distribution of noise levels is the same among that group as in the UK, then there may be as many as 580 million globally with at least a mild hearing impairment.

Social noise exposure has been increasing over the last 10-15 years, including in more developed countries; a recent study in the UK showed that this occurred particularly through attendance at discos and to a lesser extent through the use of personal stereos.

• Personal information and history

The figures obtained from such calculations and evidence above demonstrate that hearing impairments should have a high public health priority due to their high prevalence. Noise, in all its forms, has an influence on the prevalence of hearing impairment, increasing the risk of mild-moderate impairments substantially. This risk factor, which is probably the major preventable risk, can be reduced by a combination of legislation and education concerning occupational and social noise.

However, before programmes to address these issues can be undertaken there are a number of major epidemiological research needs that must be addressed (see box 2).

The study design for epidemiological surveys should include consideration of appropriate sample

selection, stratification, attendance and non-response, appropriate audiometry (with calibration of all equipment), clinical interview and examination, a noise exposure history, and tracking /follow-up of subjects. The specific data that are needed are listed in box 3.

- Demographic/personal data, age & date of birth, gender, occupation
- Presence of ear disease (including in childhood), use of ototoxics, infectious illnesses (mumps, meningitis, measles)
- Presence of tinnitus, imbalance, subjective hearing loss
- Visual problems
- Whether a hearing aid was considered
- **Family history**, especially for ages less than 55 years
- **Occupational history**: (for each task) activity, noise level - how assessed, continuity, years, days per week, hours per day, protection, after-effects, noise-trauma
- **Social noise history**: source (eg rock music, disco, headphones), noise dose (level & total time exposed)
- **Clinical examination**,
 - otoscopy, tympanometry, audiometry (air conduction at 0.5, 1, 2, 4 kHz, plus at least one of 3, 6 and 8 kHz)
 - Location of testing
 - audiometer & headphones used, booth (if any), time since last significant noise
 - whether tinnitus at time of test
- **Calibration** of sound-level meters, audiometers, headphones

4 REPORTS FROM REGIONS⁶

4.1 AFRICA REGION

4.1.1 Noise exposure

Exposure to noise causing noise-induced hearing loss in African countries can be divided into the following categories:

A. *Small-scale industries (informal sector):* The majority of Africans work in small-scale industries such as motor vehicle repairers, carpenters, metal artisans, sugar-cane crushers and corn mills. These workers (e.g. the Jua Kali in Kenya and carpenters at Anloga, a suburb of Kumasi in Ghana) have repeated exposure to high noise levels.

B. *Formal industrial sector.* (i) Manufacturing. Manufacturing factories in Africa that may cause exposure to high levels of noise include textile factories in Ghana, Kenya, Nigeria, South Africa, Swaziland, Tanzania and many other countries, and cocoa-processing factories such as in Ghana, Côte d'Ivoire, Nigeria, etc. (ii) Mining and quarrying industries can be found in Ghana, South Africa, Swaziland, Zimbabwe, etc., and every country in Africa has construction workers. (iii) Other professionals who are exposed to hazardous noise are the military, the police, fire-fighters and aviation workers.

C. *Sources of non-occupational noise.* (i) Recorded high-volume music, church bands and leisure activities such as hunting are hazardous. (ii) Exposure to noise from traffic during travel between home, work and school. (iii) Exposure to noise from some home-based activities (eg use of noisy toys by children in some African homes)

4.1.2 Strategies for Prevention of NIHL

Considering the damaging effects of noise on hearing, it is necessary for governments in African countries to enact laws to protect those at risk and define the features of occupational noise exposure and hearing conservation programmes. The primary motive for industrial noise control and related programmes is that of protecting the health of employees and reducing the likely legal liability of employers (where the laws exist) who may be held accountable for the impairments or disabilities incurred through employment. The major social value underlying protection from workplace noise is that an employee should not have to risk injury to earn a living; another is that of avoiding deterioration of job performance because of reduced sensory ability. Countries such as Seychelles and Swaziland are attempting to make such laws very effective.

⁶ Countries are grouped according to the WHO region to which they belong. For further information see the World Health Report 1997, pages 108-119 [WHO, Geneva 1997].

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Occupational strategies

Hearing conservation programmes for occupational settings must include the following interactive components:

- *Noise surveys* to determine the degree of hazardous noise exposure by surveying any area in which workers are likely to be exposed to hazardous noise (>85 dBA). Level of hazard depends on noise intensity, duration of exposure during a typical working day and overall exposure during working life.

- *Engineering and administrative controls* are undertaken to reduce exposures to <90 dBA, and include: design of equipment, its location and layout, selection of quieter machines, treatment of noisy rooms, administrative controls, proper maintenance and isolation of the worker from noise source.

- *Audiometric tests*, by pre-employment and periodic follow-up testing by employers, to help determine employee effects; employee medical history and non-workplace noise exposure should be assessed.

- *Company-sponsored education programmes* to stress the importance of good hearing conservation practices on and off the job and inform employees about other factors or diseases that may affect their hearing.

- *Hearing protection devices* to reduce the amount of sound reaching the ear. Employees having noisy hobbies, or with noisy second jobs, should be encouraged to use effective hearing protection during this noise exposure as well as at the work-place.

All parties concerned - government, employers, workers and factory inspectors- should be involved in implementing noise control measures using the "bottom-top" approach.

Non-occupational strategies

Hearing loss from non-occupational noise is common in African countries, but awareness of the hazards is low. Strategies in the non-occupational setting should include the following:-

- Education programmes targeted towards children, young people, parents, hobby groups and professionals in influential positions, such as teachers, physicians, audiologists, engineers, other health-care professionals, architects and legislators.

- High-visibility media campaigns to develop public awareness of the effects of noise on hearing and the means for self-protection.

- Prevention of NIHL should be part of the health curricula in pre-university institutions in Africa.

- Self-education materials for adults should be readily available.

- Assisting consumers in purchasing quieter devices.

- Legislation to control environmental noise and at certain spectator events.

- Training more audiologists, audiology technicians and ENT surgeons.

- Assistance from NGOs to establish audiological facilities in developing countries.

4.2 AMERICAS REGION

4.2.1 North America

In the USA, the Walsh-Healey Public Contracts Act 1969 specified a maximum

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permissible exposure limit (PEL) of 90 dBA and a 5 dB exchange rate⁷. In 1972 the US National Institute for Occupational Safety and Health (NIOSH) published its noise criteria, with a recommended exposure level (REL) of 85 dBA. The criteria defined a hearing conservation programme that included exposure monitoring, noise control, audiometric testing (baseline pre-employment audiogram and every 6 years afterwards), personal hearing protection, training and record keeping. In 1972 and afterwards, the US military adopted 85 dBA PEL with a 5 dB exchange rate, and during 1988-95 this was changed to 85 dBA PEL with a 3 dB exchange rate.

In 1998 NIOSH recommended 85 dBA REL with a 3 dB exchange rate, defined a hearing loss prevention programme, redefined the significant threshold shift and recommended derating the labelled Noise Reduction Rating (NRR) for hearing protection selection.

The Occupational Safety and Health Administration (OSHA), within the Department of Labor, is the US law enforcement agency responsible for protecting the safety and health of much of the US work force. The Mine Safety and Health Administration (MSHA) proposed in 1997 to use OSHA criteria for exposures and elements of the OSHA hearing conservation programme, although placing primary emphasis on noise control.

The U.S. Environmental Protection Agency (EPA) has regulatory responsibility for the labelling of hearing protector NRRs. While there is general recognition in the United States that the protector testing and labelling regulation needs updating, there has been no office or staff at the EPA to undertake regulatory reform since the EPA Office of Noise Abatement and Control was closed in 1983.

In Canada, not all provinces have regulations for noise exposure and hearing conservation. British Columbia revised its regulations in 1996 to 85 dBA PEL with 3 dB exchange rate and requires companies to have written hearing conservation programmes; it uses an A/B/C rating system that evaluates protector attenuation, noise exposure level, and hearing loss in selecting protection. Some other provinces have similar PEL and regulations close to some of those for USA.

4.2.2 Latin America

Isolated studies have indicated a high prevalence of noise-induced hearing loss in Latin America. There are many challenges in planning a prevention programme:-

- problems assessing accurately the magnitude of the problem because of difficulties in getting exposure history information, conducting longitudinal studies and poor record keeping (records are often inconsistent, imprecise, lacking in detail, and not computerized).

- shortages of adequately-trained and enthusiastic technical and enforcement personnel, high turn-over, poor access to literature.

- poor enforcement of occupational health legislation

- poor communication and trust between companies and employees

- young work force.

Improvements have occurred in some countries in the region following democratisation:-

- unions may now address health and safety issues

- occupational health services are generally improving, with worker participation and changes in legislation and enforcement

Increased awareness of the risk of noise-induced hearing loss has had positive effects with more cases reported and more compensation claims, but also negative effects through discrimination against workers with hearing impairments. Other problems, also found in developed countries, include companies relying too heavily on personal hearing protection rather than controlling exposure, overlooking the importance of education and training, rarely

⁷ The exchange rate is the increment or decrement of decibels that requires the halving or doubling respectively of exposure time

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evaluating adopted strategies, and a lack of tools for assessing risk and promoting prevention. A practical guide to these issues is available⁸. Recently, information management systems have been developed that allow integration of items such as audiometric records, exposure and medical histories, and hearing protection use.

4.3 EASTERN MEDITERRANEAN REGION

4.3.1 Egypt

Noise is an important cause of environmental pollution in the Eastern Mediterranean countries, especially in urban centres.

In Cairo, Egypt, sources of noise (and air pollution) are the industrial complexes located at the northern and southern ends of the city. Other cultural, social and urban activities generate varying and additional levels of noise. Noise levels were measured in Cairo and Amman in 1984, 1988 and 1991 for 10-hour periods in residential and commercial areas. Noise levels were 72-80 dB (A) in the early morning and 74-88dB(A) during the night in residential areas. In commercial areas, the noise levels reached a peak of 92dB(A), fluctuating down to 76dB(A) from noon to 3 p.m. In 1984 noise-exposed workers in a forge-hammering plant showed hearing impairment in the 2-4 KHz range. Orchestral musicians in 1991 showed significant differences in pure-tone thresholds between the musicians and control group especially amongst percussion and brass players. In a national newspaper, noise levels were highest in the printing room, and workers here showed mild to moderately high frequency hearing loss, or a v-dip at 4kHz, depending on the duration of exposure to noise.

In Amman, Jordan, noise levels reached a peak of 81dB(A) from 8a.m. to 12noon. Generally speaking, Amman has low noise levels.

4.3.2 Pakistan

In Pakistan, increasing urbanisation has resulted in substantial increases in noise levels in cities such as Karachi, Lahore, Faisalabad and Peshawar. Road traffic, especially auto-rickshaws which do not have silencers, produce a noise level of up to 100-110 dB. On the day of a transport strike, Karachi Leq declined from a usual level of 90 dB to 75 dB. Leisure noise, such as from loud-speakers (buses, minarets, rock bands, personal stereos) and from gunfire at weddings are significant noise sources. It was observed that certain ethnic groups of African origin do not sustain so much noise trauma as subjects with other ethnic origins in identical environments.

Industrial noise in Pakistan is greatest in its large textile industry (from weaving looms), steel mills and airports in the largest cities. For example, average noise levels in different sections of a textile mill in Karachi were found to vary between 85 and 112 dB (mean for all sections 99.1 dB). In the sheet metal industry, 8% of workers were found to be hearing-impaired due to noise. Another study of Karachi textile workers found that 22% of those exposed to noise had noise-induced hearing loss compared to 2% of controls. Over half of the cases with noise-induced hearing loss also had tinnitus. Subjects with other causes of deafness and hearing impairment were excluded.

Legislation for hearing conservation in industry and compensation for noise-induced

⁸Franks J, Merr C, Stephenson M. Preventing Occupational Hearing Loss. A practical guide. DHHS, NIOSH Publication no. 96-110, Cincinnati, 1996

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hearing loss exists but is seldom enforced. Compensation can only be paid for "absolute deafness" which is extremely rare. An increase is needed in public awareness and education, campaigning at political forums (provincial and national assemblies), and the improvement of legislation and the proper implementation of hearing conservation programmes.

4.4 EUROPEAN REGION

Mandatory directives in European industries have improved noise emission levels over the last two decades and reduced the risk of damage to hearing by providing hearing protection for workers. However, environmental noise including that from traffic and recreational activities has been increasing, as have the number of complaints from the public. Noise pollution has had a much lower priority than air and water pollution.

Although the data available for noise exposure is poor, it is estimated that some 25-35 million people work in potentially dangerous noise environments and around 20% of the European Union's population (around 80 million people) suffer from noise levels which may be health hazards due to annoyance, sleep disturbance and cardiovascular changes.

The estimated costs of noise to society, especially transport noise, range from 0.2% to 2% of GDP which for the lower figure is over 12 billion ECU annually. Noise induced hearing loss is a significant cause of disability and represents the largest single category of compensated occupational diseases.

In the European countries leading the hearing conservation programme, such as Sweden, large investments were made in the 1970s to reduce noise levels which by the 1990s were 3dB (A) lower from industrial machinery and around 10dB (A) lower from vehicles. In the 1980s, hearing protective devices became available but their usage in industry remains low and patchy with little awareness of the dangers to hearing if ears are left unprotected.

Statutory controls in industry, in place since the 1970s, have limited the time and level of exposure for a worker, but control of noise nuisance in the community has only recently been introduced and remains within the power of the Local Authority. The improvements made in industrial noise have been offset by the increasing levels of noise pollution from traffic and modern leisure pursuits especially amongst the young. The latter group is of growing concern since, at a later stage, they may work in noisy industries, thereby creating an ever increasing number of sufferers from noise induced hearing loss.

It is clear that noise pollution must be given a higher priority worldwide. A framework for action must be prepared which seeks to use all available information to reduce noise and its detrimental effects on humans.

4.5 SOUTH EAST ASIA REGION

4.5.1 India

Only a few reports from India give statistical data regarding the incidence and etiology of hearing impairment. These are generally on a state or district rather than national basis. However, an Indian Council of Medical Research (ICMR) report in 1983 found the proportion of hearing impairment to be 10.7%. A study by Kacker (1989) found hearing impairment to range from 13.5% to 18.5%. Sensorineural loss was more common in the urban population, whereas conductive loss was more common in the rural population.

A 10 year study of noise-induced hearing loss in coalfield, steel plant, textile and pharmaceutical industry workers and natural oil and gas plants found that the amount of noise trauma depended on intensity and also on characteristics of noise, duration of exposure,

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dimensions of the workplace, age, sex, temperament, susceptibility and personality. Another study of 430 patients conducted by Srivastava at Bokaro Steel Plant found a 37% incidence of mild to severe sensorineural hearing loss.

The ICMR promotes occupational and environmental health research. With rapid industrialization and urbanization, this has assumed increasing importance in recent years. One component is the pioneering work of The National Institute of Occupational Health, Ahmedabad, in the area of industrial noise, i.e. exposure and risk assessment, and interventional studies.

Preventive measures for NIHL. The prevention of NIHL should occur in any industry producing noise above 90dB, with measures at the engineering, personal and administrative level. Governmental and nongovernmental agencies and the media should extend public awareness of the hazards of noise. Posters and play cards should be displayed in working places. There should be clear legislation regarding noise pollution and NIHL.

In most places in India the international standard for safety from noise exposure is recognised and noise-induced hearing loss has also been incorporated into the Indian Factories Act (1996 amendment) as a notifiable and compensatable disease.

Since most Indian employees are illiterate, they are ignorant about the impact of noise and neglect the hazards of noise pollution. Lack of communication between the authorities and the masses adds to the problem. Nongovernmental organizations and the private sector should provide statistical data periodically to update the Ministry of Health on noise hazards. Specific needs include (1) mandatory pure tone audiometry for all new employees, (2) audiological assessment at least once a year, (3) Intensive public awareness campaigns via different media, (4) Maintenance of records.

Guidelines should be issued by WHO to governments, to heads of institutions and to private sector agencies on the updating and implementation of legislation and compensation relating to NIHL. Professional societies should organize workshops, symposia and meetings, in collaboration with the Ministry of Health, to create awareness of the problem. A national noise control programme should be started.

Noise-related problems are attracting attention from all sectors of society. We now need the enactment and enforcement of legislation for the maintenance of environment-friendly, less damaging and low noise in the working place.

4.5.2 Thailand

Thailand started becoming a semi-industrialized country over 2 decades ago. Many people migrated from rural areas to Bangkok and noise there, due to traffic, construction and industry has become a big problem. The National Environmental Board of Thailand includes the study and control of noise problems and has recommended levels for various noise sources (eg residential area: Leq 24hr \leq 70dB(A); industry: Leq 8h \leq 85dB(A)). Damage compensation has been set up. The problem is not yet solved because of the lack of public awareness of the effect of noise on hearing and the difficulties in controlling noise.

A recent study for the National Committee on Noise Pollution

Type of work	Number of subjects	Mean age (range)	Mean weight (range)
Foundation constructors	19	25.5 (14-42)	3.0 (11)
Expressway constructors	31	29.0 (17-48)	3.5 (21)
Building constructors	43	27.9 (14-39)	3.0 (10)
Brewery workers	45	33.3 (14-55)	15. (11-54)
Oil refinery	5	37.7 (22-58)	12. (31)
Department store	23	26.0 (19-54)	5.8 (15)
Music Department	53	27.6 (18-42)	4.0 (22)
Residents - business area	73	39.7 (14-64)	12. (11-38)
Residents - China Town	33	38.3 (12-54)	13. (33)

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Control measured noise exposure and hearing impairment in various occupational groups and found 21.1 to 37.7 % with noise-induced hearing loss (defined as a 4kHz notch, i.e. 20dB worse than at 2 & 8 kHz), see table 1.

4.6 WESTERN PACIFIC REGION

In Japan, numerous studies on noise control or hearing conservation at noisy workplaces have been done recently. New administrative guidelines (Notification of the Labour Ministry of Japan) for the prevention of noise-induced hearing loss were issued in 1992 and are summarised as follows.

The guidelines cover workplaces and their workers where the noise level as measured by $L_{Aeq,8h}$ is not less than 85 dB (including outdoors). Standard environmental control values are, first: L_{Aeq} 85dB; second: L_{Aeq} 90 dB. The "personal" standard value for permissible exposure is L_{Aeq} 90 dB. The standard value for hearing conservation should be based on the hearing level.

In order to apply the standards, workplaces are selected in which the highest noise level in the environment is L_{Aeq} 85 dB or more; workplaces in which the level exceeds L_{Aeq} 85 dB are made the subject of control. Workplaces are divided into 3 divisions such that the noise level at all of the points measured is:- Division I: not more than the first control standard value; Division II: not less than the first and not more than the second; Division III: more than the second. Data for environmental measurement are also utilised to evaluate the "personal" amount of exposure to noise. Hearing tests are carried out on workers subject to exposure to noise in Divisions II or III.

Noise levels in workplaces belonging to Divisions II and III are measured once every six months and when the noise level changes with changes in mechanical equipment and methods of work. Workplaces in Division II make efforts to bring their noise levels below the first control standard value (L_{Aeq} 85 dB); those in Division III bring their noise level to below the second control standard value (L_{Aeq} 90 dB). Where the noise level at a workplace exceeds the second control standard value despite improvement measures, the total exposure of the individual worker must be reduced and the noise level brought down to the level below the standard amount for the permissible exposure (L_{Aeq} 90 dB), by limiting the exposure time through adjustment of the work allocation plan or by using hearing protectors. In workplaces in Division III, wearing of hearing protectors is compulsory.

Hearing tests, by pure-tone audiometry, are conducted at the time of employment, and relocation, in principle once every six months. Those with slight decline in hearing are encouraged to use hearing protectors; those with a worse decline in addition have their exposure time to noise shortened.

For workers and supervisors, education and training is given periodically on the prevention of hearing impairment, effects of noise on the human body, securing and maintaining a proper work environment, using the hearing protector, actions following the hearing test, prevention of disasters arising from communication problems in noisy workplaces.

Compensation

Various workers' accident compensation insurance schemes in Japan oblige the employer to assume responsibility for compensation for a labour accident suffered by the worker concerned. Compensation for noise-induced hearing loss is paid when the mean hearing level (6-divided average) is 40 dB or more at the time the worker concerned retires from the noise-producing workplace. Table 2 presents the number of cases by industry in which compensation, pursuant to the Workers' Accident Compensation Insurance, has recently been paid.

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Table 2. Types of workplaces of cases of noise-induced hearing loss for whom insurance was paid

Types of workshops	1987	1988	1989	1990	1991	1992	1993	1994	1995
Forestry	1		3		2	4	1	5	3
Mining	28	38	17	32	32	27	22	35	21
Construction	45	43	38	29	37	47	67	118	162
Manufacture (shipbuilding)	1123 (682)	752 (522)	340 (178)	183 (80)	173 (68)	172 (62)	128 (49)	132 (69)	173 (89)
Conveyance	2	2	1	2	1	1	1	1	1
Miscellaneous	137	129	31	50	45	35	26	29	38
Total	1336	962	430	296	290	286	244	317	397

The annual variation is partly related to the numbers of workers retiring in a particular year, and not necessarily to the occurrence of noise-induced hearing loss in that year. Most cases have developed over many years. Noise-induced hearing loss is seen largely in the manufacturing industry, particularly the shipbuilding industry, where there have been substantial retirements due to the economic depression. For classification for compensation, the hearing loss in both ears is divided into six stages (nine divisions); the hearing loss in one ear is divided into four stages; and a division is provided for speech discrimination. The compensation is based on the average daily wage after retirement and ranking of disability and paid as either a yearly pension or a lump sum.

5 PREVENTION AND MANAGEMENT WITHIN PRIMARY HEALTH CARE

5.1 Introduction

Primary health care (PHC) embodies health care at the community level, access for all, and prevention and cure of common disorders. It includes advocacy for health, health education, and encouragement of related behavioural and environmental changes. The key elements for prevention of noise-induced hearing loss are shown in box 4. Prevention of noise-induced hearing loss must be appropriate (i.e. it makes sense), adequate (it makes a difference), acceptable (one can live with it), and affordable (to the individual and community).

<ul style="list-style-type: none"> • limit duration • avoid situations of excessive noise
<p>Use protective devices</p> <p>These must be:-</p> <ul style="list-style-type: none"> • appropriate... • acceptable... • affordable... <p>...at community level</p>
<p>Control excessive noise</p> <ul style="list-style-type: none"> • location of sound source away from exposure • sound insulation • noise-reduction technology

5.2 Individual strategies for prevention and management in non-occupational settings

Noise-induced hearing loss (NIHL) is the result of exposure to high sound levels at all ages. The individual's actual hearing reflects different noisy, possibly harmful, factors related to heredity, children's noise exposure from toys and games, military service, occupational noise, and recreational activities.

In general, it is believed that noise in the military and occupational environments has decreased due to better hearing conservation programmes, improved ear protection, and better compliance to regulations. By contrast, there is much less indication of improvement during recreational activities, mainly due to lack of regulations and awareness, and poor ear protection. Due to the commonly very short duration of **impulsive noise**, the levels are underestimated and the possible harmfulness increases, particularly with shooting (up to two-thirds of industrial workers in the USA have shooting as a hobby). However, there are few prospective studies on the effects of gunfire. Possibly harmful **continuous noise** may occur during leisure activities, but exposed people are generally more aware of the possible risks than with impulsive noise. The risks of NIHL from listening to music have been overemphasized and here tinnitus and hyperacusis are more likely.

The best-known and "easiest" prevention of NIHL is from **ear protection**, although its disadvantages (discomfort, poor sound quality and low-frequency discrimination) often result in poor fitting and use. Better motivation for prevention of NIHL during recreational activities is needed, although scare tactics, similar to those used against smoking, may not be the best means of prevention. Many people, particularly young men, are opposed to preventive measures, since they are considered to decrease the enjoyment of the activity. Further, many developing countries apparently have greater needs for many health care improvements other than prevention of NIHL.

Consequently, it is an important and challenging issue to improve information about the wonderful sense of hearing. Good hearing is often taken for granted and a possible hearing loss is not taken seriously by young people. In comparison to research on the anatomy and physiology of the ear as well as our comparatively good understanding of NIHL, our knowledge of the best ways to influence attitudes about noise and recreational habits is quite poor. Much more emphasis should be given to improving people's appreciation of the value of good hearing,

their attitudes to noise, and knowledge about NIHL and its consequences and prevention. This is an important challenge for primary health care and not only in developing countries.

5.3 Environmental Strategies

In one sense, environmental strategies for preventing noise-induced hearing loss encompass all the areas addressed in this section since it can be argued that all exposures containing sufficient acoustic energy to cause injury should be included in the category of "environmental noise". Occupational noise exposure, by this definition, is just one example of an environment, the workplace, where a person may be exposed to hazardous noise. Listening to amplified music through earphones, represents another type of environmental exposure, but here affecting only one person - the listener. These areas are covered in the other two sections of this workshop.

This section summarizes current knowledge and present strategies for preventing noise-induced hearing loss amongst groups such as children at school and persons at sporting events who are exposed to non-occupational, and non-individual environmental noise.

(1) Children at school. There is concern but few data regarding the types and quantities of noise to which children are routinely exposed during school hours. Hearing ability declines with age, starting in infancy, but it is not certain how much of the decline is due to ageing and how much to excessive noise. Recent studies suggest that, during school activities, children are routinely exposed to noise levels above those recommended as "safe" by the US Environmental Protection Agency and that children may receive more noise at school than from an eight-hour work day at a factory. The school environment may be excessively noisy during a bus ride to and from school, at assembly, shop or music classes, and in the classroom itself. Other school activities, before and after school, can be quite noisy such as sporting events like swim meets, and latchkey programmes. More research is needed on the total exposure of young people to leisure noise.

A survey was recently conducted by the Central Institute for the Deaf, St Louis, USA of daily noise exposure in 110 children age 6-14 years. Each child wore a personal noise dosimeter from rising until bedtime on a school day. Noise exposures have also been measured during hockey games, at summer day camps and during swim meets. There was widespread exposure to loud sounds. Exposures above 90 decibels (the line between "always safe" exposures and "possibly hazardous" exposures) were commonly encountered in the lunchroom and gym; the average noise exposure measured over a 24-hour day (L eq 24) for all children was 87.4 dBA and, during recess, some exposures exceeded 115 decibels (L eq 1 min). Thus, it is possible for children to suffer permanent hearing loss due to school activities, and steps need to be taken to quieten the typical child's environment.

(2) Professional Indoor Sporting events. For one fan at a US hockey game the Leq for the game was 99.5 dBA and the two most significant sources of noise during the game were the cheering of the fans and the loud foghorn (114 dBA) sounded after goals scored by the home team. The percentage of allowable noise, calculated by OSHA standards, was 117%. At a World Series baseball game the Leq was 96.9 dBA, and 1-min averages were as high as 114 dBA. Taken together, these data suggest that persons at professional sporting events are exposed to levels and durations that exceed most federal guidelines. These noise exposures are unlikely to be a significant risk to spectators, since they only attend periodically, but regular attendees, such as players, officials, concessionaires, ushers, ticket agents and security personnel, may be at significant risk and should be included in a hearing conservation programme.

For prevention, governments should establish and enforce standards and regulations to

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protect the hearing of their citizens. This may not be practical with non-occupational activities and here early education must be provided. It is recommended that programmes be developed to train professional "noise educators" who would combine the skills of noise knowledge, educational methods, audiometric measures, hearing protection and other preventive measures.

Such educators could emphasize the value of having good hearing and change the often poor attitude about harmful sounds encountered in all age groups both in and out of the workplace. Attitudes among young people which favour loud sounds must be changed to protect their hearing later in life.

5.4 Occupational Strategies

Protection Against Noise (PAN, Europe, 1996) a European Union Concerted Action, consists of 24 Research groups (coordinated by Dr Deepak Prasher, University College, London) which deals with the comparative analysis of current hearing conservation strategies, and integrated data collection. It covers acoustics of NIHL, clinical identification, susceptibility, risk factors, interaction of pathological processes, effective preventive measures, and rehabilitation.

The US National Institute on Occupational Safety and Health has redefined research priorities (NIOSH, 1996) and produced a practical guide: *Preventing Occupational Hearing Loss*. As well as focussing on prevention, it gives a broadened risk evaluation, provides emphasis to education and training, and offers alternatives for evaluating effectiveness of hearing loss prevention programs. It also deals with emerging trends and technologies which include eligibility / availability of hearing loss prevention programs, record keeping (by optical card), sophisticated computer programmes (Noisescan, HEARSAF), combined exposures, exposure assessment models, hearing protectors, education and training. A web-site on HEARSAF deals with these issues in greater detail especially in relation to assessing validity of audiometry, obtaining an overview of the hearing loss prevention programme in order to assess the effectiveness of interventions, and providing epidemiological information. The internet address is: <http://www.cdc.gov/niosh/hearsaf.html>

5.5 Detection & Monitoring

The traditional conservation model was proposed by NIOSH in 1972, and employed by OSHA, MSHA, and the military. Monitoring hearing loss consists of a noise-free baseline audiogram, followed by annual audiometric testing, calculation of threshold shift, and action on confirmed age-corrected threshold shift. Even the best of programmes result in "audiometric voyeurism" and are driven by failures; that is taking action only when someone is found to have a threshold shift. In the U.S. there is currently no regulatory pressure for noise control below 100 dBA, and incomplete implementation of hearing conservation programmes. Employees may be seen as objects to which the programme is applied and obstacles to programme implementation. There is currently no national database since there were no regulations that required NIHL to be reported.

Table 3 (next page) compares the compliance approach with the prevention approach for those situations where reducing the noise levels to below 85 dBA has not been successful.

Monitoring and Detection should include both environmental and medical surveillance; the outcomes of both drive programmes. Environmental surveillance (which should also document other hazardous exposures such as toxic chemicals) enables elimination of hazard. Medical surveillance enables detection of temporary threshold shift to avoid permanent threshold shift. Audiometry should be used as an early warning detection of temporary threshold

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shift which is always a precursor of permanent threshold shift. However temporary threshold shift is not predictive of the *magnitude* of permanent threshold shift.

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Table 3: Comparison of the compliance approach with the prevention approach to detection and monitoring

COMPLIANCE APPROACH	PREVENTION APPROACH
1 Regulations	
Standards to be achieved	Minimum standards
2 Focus	
Policy methods, means, and materials set by the company; employees have no role, their compliance is forced or demanded	Employees are primary partners in establishing policies, methods, and means, and selecting materials and strategies
3 Processes	
3.1 Monitor the hazard, develop removal strategy only if exposure levels exceed 100 dBA TWA8 [8 hour time-weighted average, 5-dB exchange rate]	3.1 Remove the hazard; If hazard cannot be removed, establish and re-establish extent of hazard
3.2 Include all exposed workers in programme, establish dose through representative monitoring	3.2 Establish exposure profiles for each employee using Task-based Exposure Assessment Models.
3.3 Provide protection to all employees with exposures of 90 dBA TWA8, or 85 dBA TWA8 for those who already have standard threshold shift.	3.3 Fully brief employees of hazard and provide training on use or methods and materials that may be deployed to prevent hearing loss. 3.4 Customize intervention strategies including protection to all exposed to over 85 dBA. 3.5 Optimize effectiveness of personal protective equipment by individual fitting and fit checking
3.4 Provide annual audiometry:- <ul style="list-style-type: none"> • compare to baseline for standard shift, no immediacy • age-correct to reduce incidence of shift • follow-up on audiograms with shift up to 1 year later • perform audiometry before work period to avoid dealing with temporary threshold shift 	3.6 Provide annual monitoring audiometry during work period (biennially for those exposed to noise levels greater than 100 dBA) <ul style="list-style-type: none"> • check immediately against baseline for shift • if shift, refit, reinstruct, retest • explain test results and subsequent actions immediately, regardless of test results • if still shift, reschedule for follow-up • if shift not confirmed, begin work to prevent further TTS (temporary threshold shift)

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COMPLIANCE APPROACH	PREVENTION APPROACH
	<ul style="list-style-type: none">• if shift confirmed, begin work to prevent further loss <p>3.7 Provide audiometry at other times:-</p> <ul style="list-style-type: none">• whenever entering new noise area• whenever leaving noise area for extended time• at termination of employment, if possible
	<p>3.8 Send hearing loss prevention message home so that employee and family are aware of the importance of actions they can take to prevent loss of hearing due to recreational and social activities. Provide hearing protectors for use against non-workplace noise.</p>
	<p>3.9 Express company attitude of zero tolerance for hearing loss; there is no acceptable level of threshold shift due to noise.</p>

6 DEVELOPMENT OF A NATIONAL PLAN FOR PREVENTION OF NOISE-INDUCED HEARING LOSS

6.1 Perspective from a developing country: (1) Kenya

The main sources of noise in Kenya are:-

- social - discotheques, individual music, hobbies, music in "matatus" (communal taxis)
- occupational - formal sector: various industries; informal sector: "jua kali" (open air)
- environmental -traffic noise, night club environs

The Ministry of Labour and the Department of Occupational Health of the Government of Kenya are involved. The Department of Occupational Health carries out noise surveys in some industries. Audiometry is limited to certain workers who are transported to the Department for the purpose. In September 1996, the Ministry of Labour promulgated Legal Notice 296 setting out guidelines for the prevention of NIHL. A 90dB limit for 8 hours exposure and a 5 dB exchange rate was gazetted. When compensation is paid this is usually by an out of court settlement which includes a ban on reporting the case in the media.

The Kenya Ear Foundation started a project against occupational noise-induced hearing loss in 1993. The package consists of a free noise survey of the establishment, audiometry on site (at US\$2 per head), free ear plugs with advice on their use to the "first time tested worker", an audio-visual talk to workers on the need for hearing conservation and use of protection, and a report to the Chief Executive of the establishment. The foundation has also sent out many letters to industry, spelling out the need for hearing conservation and the services offered by the project. Articles on sociococcus and the baneful effects of noise have been supplied to the local media. There has been difficulty in persuading industry to participate in the programme and there has been no tangible support from the Federation of Kenya Employers nor from the Kenya Association of Manufacturers. The project has not been discussed with the Trades Unions in order to avoid labour unrest. It was hoped that management would be more likely to participate with such an approach, but this may be reviewed.

In addition KEF has lobbied for the Legal Notice mentioned above and also an on/off switch for the control of noise in Matatus.

Some needs and solutions for these problems could include:-

- Creation of public awareness. Governments, NGOs, WHO and the media have a role here
- WHO country representatives assisting governments to implement the World Health Assembly Resolution on Prevention of Deafness⁹
- A positive interest by Government
- Creation of an enlightened and caring management and an informed worker (the ILO and the local employees Association may be involved here).
- Involvement of the Trade Unions
- Universities and national ORL bodies should initiate research studies in this field.
- For developing countries, a Hearing Conservation Programme is the most cost-effective option.

⁹ *Prevention of Hearing Impairment*, Resolution of the World Health Assembly on 12 May 1995, number WHA48.9

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6.2 Perspective from a developing country: (2) Pakistan

In Pakistan, noise is a major cause of hearing impairment. The main sources are industry, road traffic (eg auto-rickshaws often without silencers, buses, trucks, motorcycles, roadside workshops), social & leisure noise (eg personal & group music amplification, religious gatherings, political activities, weddings, use of firearms) and bomb blasts.

Prevention and conservation strategies can be applied at the source of noise, along its path, and at the receiving end (see box 5).

Various legislation has been passed in Pakistan against noise in 1965 & 1969. This provides for the elimination of excessive vehicle noise, use of silencers, prohibition of certain audible signals at certain times, especially multitone/musical horns, no music on public vehicles. Earlier legislation covered employers's liability, specifying details of injuries, nature of the disability, (partial, total, temporary, permanent) and a formula for compensation. However, at present, any loss that is less than 100% loss of hearing is not considered for compensation; partial disability is not allowed.

6.3 Perspective from a developed country

Over the past two decades there has been increasing concern about the role of non-occupational or leisure noise in producing noise-induced hearing loss. The most common sources of this type of noise are exposure to live or amplified rock, classical or jazz music; exposure from personal listening devices ("walkman" type); noise around the home, hobbies, at schools and kindergartens, in traffic, hunting and target shooting, etc. Some toys produce such loud noise that even short exposure may cause a hearing defect.

The hazards caused depend upon the level of noise and duration of exposure. Impulse noise from shooting may quickly result in hearing damage. In Finland, the noise exposure value in workplaces is limited to 85dB (8 hours of equivalent level).

The damage to hearing caused by noise develops unnoticed during the course of several years. Exposure to continuing noise over a long period increases the risk of hearing damage. Noise also greatly disturbs communication, especially among hearing impaired people, but among hearing people too. In addition to hearing damage, continuing noise also affects sleeping and causes stress, tension, tiredness and high blood pressure.

Noise is not recognized as a very significant source of environmental pollution even though there are many sources of noise surrounding us in developed countries. The loss of hearing is increasingly caused by acquired defects such as noise. For instance, in Finland only a few dozen children are born each year with a serious hearing impairment but one-fifth of young men are found to have hearing difficulties. Thus, deaf people are decreasing in number but hard of hearing people are increasing, being at least 10% of the population.

People have more leisure time, their hobbies are noisier than before and their entire

Traffic

- ban on vehicles without silencers
- proper repair and maintenance of vehicles
- proper planning of roads
- ban on horns and hooters.
- banish roadside workshops

Industry

- maintenance of machinery
- noise enclosures
- air exhaust mufflers
- vibration damping techniques
- other noise protecting devices
- education at the work place
- strict implementation of government regulations.

Leisure

- Label hazardous recreational power tools
- Declaring social and religious activities to be noise free
- Educate children on hazards of personal music systems

CONTROL ALONG THE PATH

- Absorption of noise (eg air gaps, absorbent material, hanging absorbers in factories)
- Barriers (eg walls, earth mounds, islands, plantations, rerouting)

CONTROL AT THE RECEIVER'S END

- pre-employment screening
- ear protection, for above 85dB: ear plugs/muffs/defenders (assure safety, ease of use, comfort, effectiveness, penalties for non-compliance)
- education & training in their use
- periodic audiometric check up
- avoid noise exposure for high risk persons

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amount of noise exposure - taking into account both working hours and hobbies - is high, especially for young people. However women have less hearing loss caused by work than men.

In Finland, noise and its prevention is referred to in 16 laws and some bylaws, especially legislation concerning traffic, places of working, communal responsibilities, planning and follow-up. For the implementation of laws people must be aware of them and their rights as consumers, how to put them into practice and how to protect their hearing themselves. Because unemployment is high, workers often do not complain for fear of losing their jobs.

Local authorities collect information and make plans for noise prevention at a local level. More examples of good practices need to be developed through cooperation between different authorities and citizens, who should be encouraged to assume an active role themselves.

The Finnish Federation of Hard of Hearing People is a member of the Finnish National Council for Noise Prevention and in 1995 started a project called *CREATING AWARENESS ABOUT THE ROLE OF NON-OCCUPATIONAL OR LEISURE NOISE ON HEARING*, in cooperation with the Ministry for the Environment, the National Board of Education, the National Consumer Organization, teachers and health care personnel in schools, the Ministry of Labour, the Occupational Health Institution and many experts from universities and different institutions. About 500 school teachers and health personnel in schools took part at a local level. Approximately 2 million people in Finland became aware of the project through newspapers, TV and national and local radio. (See box 6 for objectives, target groups and methods of the project.)

The project included:

(1) Training Courses for health care personnel in schools and nursery schools, teachers, disc jockeys, musicians and sound engineers. Training topics were: How noise damages your hearing, the psychosocial effects of noise, voice as a physical phenomenon, how to measure noise exposure, the equipment of sound production and how to measure the sound pressure, acoustic surroundings, laws concerning noise and the protection of hearing. Subsequent feedback meetings reflected on how the quality of working conditions and hearing protection in discos, restaurants and other places had been improved.

(2) Regional training courses for the public about noise and tinnitus.

(3) Research projects:

- A survey on "How hearing impaired people can hear in noisy surroundings".
- A survey on young people's leisure noise exposure by the University of Kuopio.
- A survey on leisure noise exposure to manually operated machines at home in cooperation with the Occupational Health Institution, the National Consumer Administration and the Ministry for the Environment.
- A survey (begun 1997) to assess leisure noise exposure among urban adults in Finland.

(4) Material produced:

- Transparencies and information file, "What is noise" leaflet, comics, videos, & tapes for students, teachers and health care personnel in schools:

Long-term objective:

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- Wall stickers, decibel cards (size of a credit card)
 - Information leaflet for local associations of The Finnish Federation of Hard of Hearing, for music teachers and the councils of the handicapped.
 - A handbook for all people dealing with many topics of noise and protection of hearing¹⁰.
- (5) Exhibitions and happenings
- Campaigns in schools. Together with FFHOH, 500 schools organized events on the theme "How to protect your hearing". Most of these schools will continue to have an annual "Noise week".
 - Campaigns in kindergartens. 200 events all over Finland involved playing and singing and giving information to parents and children's nurses.
 - Campaigns at rock and other music festivals. In Summer 1997 information was distributed to the organizers and the audience at 20 festivals about the effects of too loud

- To decrease the noise exposure of people.

Short-term objectives:

- To prepare information for young people and adults about the prevention of hearing loss and protection from noise exposure.
- To raise awareness of the consequences of noise for health and hearing, and of possibilities to protect hearing.
- To influence young people when listening to music, in order to protect their hearing under noise exposure.
- To survey and improve hearing circumstances for hard of hearing people in public places
- To support other appropriate services.
- To disseminate the information prepared by the project as widely as possible in Finland.

Main target groups:

- Young people, musicians.
- People who work with the production of sound.
- People as consumers, and hard of hearing people.

Methods:

- Mass media campaigns (TV, radio, newspapers: interviews, articles, news)
- Campaigns in schools
- Training
- Research
- Exhibitions

music and the consequences of noise for hearing. Participants including young people were positive, musicians do protect their hearing, but organizers need much more understanding of noise exposure and its consequences, especially for hearing. Persons who control the volume of music in festivals need more information and should go for annual hearing tests because, due to their reduced hearing, they use too high sound volumes.

The main conclusions from the project were:

- most young people reacted to the project in a positive way
- More awareness should be generated, especially among decision makers, about the importance of noise exposure and protection of hearing.
- People as consumers agree that they are entitled to less noisy surroundings and protection of their hearing against noise pollution.
- More research is needed on leisure noise, particularly exposure to it, and on how to make surroundings less noisy especially in schools and kindergartens
- The media are interested, with encouragement from the Finnish Federation of Hard of Hearing People to continue programmes about noise and hearing

¹⁰ Topics covered by the handbook:- What is the voice, different voices, what is noise, how noise can affect hearing, tinnitus, other consequences of noise, hard of hearing person in noisy surroundings, how to measure noise, the noise in leisure time activities, the noise of different machines, toy noise, music, hearing damage due to use of Walkman, restaurants, discos, traffic, motorcycle race etc., laws and acts, what to do when you want to change noisy surroundings. Where to obtain more information.

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- Through good cooperation amongst different institutions and experts, increasing hearing impairment may be slowed down, in the long run.

6.4 Legislation and Compensation

Compensation has for long been paid to those whose hearing has been damaged by excessive noise. The Romans financially compensated their armourers as they recognised that working with metal had resulted in hearing loss. Industrialised countries have paid compensation for many years but particularly since the 1940s to war veterans exposed to excessive noise during World War II. In 1975 occupational deafness became a notifiable and compensatable disease in the UK.. The compensation scheme was then only payable to workers in certain occupations, (eg jute and weaving industry).

Certain criteria had to be met:-

(1) According to the work history, levels and duration of noise exposure, and the otological history.

(2) The audiological barrier. This "low fence" was originally set low but later set at 40, later still 50 dBHL average over the frequencies 1, 2, 3 kHz in the better ear.

Compensation may variously be given for hearing loss or hearing handicap. Hearing loss compensation is easy to calculate and often used in a legal case against an employer, where a "lump sum" financial settlement is sought according to the hearing loss or impairment rather than the handicap at that time, usually with the claimant agreeing to seek no further litigation against the company involved. This appears fair, but for the same hearing loss, hearing handicap may be significantly different in two cases. The lump sum payment is preferred by companies since it avoids further claims; the alternative of payment of a pension has an indefinite time-scale.

Many agreements between unions and employers often allow for the additive effect of noise damage to the hearing loss of presbycusis. In the United States there is a presbycusis correction of 0.5 dB/year above the age of 40. Compensation for a period of retraining for another appropriate job is also allowed in the USA.

The cost of compensation can be very high. For example, in Ontario, Canada the average pension paid may be as much as \$15,000 over the claimants lifetime. The costs of compensation have eventually to be borne by the involved industry in insurance fees and legal costs. Thus, for a company to control its long term expenditure, hearing preservation programmes in the work place are both sensible and cost-effective.

A noise-induced disability is defined as the difference in the disability estimated from the overall hearing thresholds of the noise exposed individual (taking into account any constitutional hearing disability), and the disability estimated from the thresholds of hearing in a median person of the same age and sex who has not been exposed to noise (standard tables are usually available from government offices for the latter). However, a simple, scientific method to quantify hearing disability resulting from the hearing impairment caused by noise has still to be developed. This means that there may be an element of "rough justice" in the process of assessment. Thus, a person who is genuinely more disabled and hence handicapped for a given hearing impairment may sometimes be assessed too conservatively. There is a strong argument for self-scoring of disability rather than disability based on certain audiometry tasks, although this may lead to measurement uncertainty. In the UK a scale has recently been proposed that relates hearing disability and hearing impairment and is based on the data obtained in the large UK National Study of Hearing.

In the US and the UK, government compensation schemes supplement the basic disability pension to a maximum limit. The amount of the pension depends upon the percentage

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hearing loss and the age and length of time for which funds are paid. In the UK, the scheme specifies which occupations qualify and requires the individual to have a hearing loss greater than 50 dBHL averaged over 1, 2, 3 kHz in both ears, which is a significant hearing loss. The percentage degree of disablement varies from 20% at 50dB to 100% at 88db or above. The scheme may appear mean on first inspection, since to qualify for the UK scheme the government set a high initial fence. However, because any pension paid would probably be for life, if paid in full it is generous. A separate, similar UK scheme was set up to compensate war veterans exposed to loud noise during war-time, but the criteria for payment under this scheme were not so rigorous. Any compensation scheme has to be fair and workable. Since 1992 in the UK it has been recognised, following a European union directive, that the individual must take some responsibility to protect his hearing and the onus of responsibility is not all on the employer

The costs of compensation for hearing loss are high but the costs of prevention can also be high. It is estimated in the United States alone that just keeping the noise levels of machines below 90 dB(A) would cost US industry over a period of time approximately 11 billion dollars.

7 PRESENT AND FUTURE NEEDS

7.1 Data Collection- (1) the Air Management Information System (AMIS) and Noise level database

AMIS is a programme developed by WHO under the umbrella of the Healthy Cities Programme with the objective to transfer information on ambient and indoor air pollutant concentrations and air quality management instruments between countries.

(See box 7) By definition, noise pollution is considered as part of air pollution within the AMIS.

AMIS has developed a set of user friendly MS-ACCESS based databases. The core database contains summary statistics of air pollution data such as annual means, 95-percentiles, and number of days on which WHO guidelines are exceeded. Any compound for which WHO air quality guidelines exist can be entered into the database. Data handling is easy and data validation can be assured. Diskettes and compact disks have now been produced. In the existing version, data (mostly from 1986 to 1995) from about 60 cities in 30 countries are represented. A report of these data will be produced. All of these items will be made available to AMIS participants and distributed to interested non profit organisations free of charge.

Data for this and other AMIS databases which are being planned (see box 8) could be collected via WHO Regional Offices and AMIS Regional Collaborating Centres. For the core database it is intended to increase the number of contributing cities to 100 by end 1997 and 300 by end of the millennium.

The noise level database has been developed recently. It will be filled with summary data such as annual and busiest month means of equivalent permanent sound levels, averaged over 8, 12, 16, and 24 hours, 10th and 90th percentiles of sound levels single event levels, number of events, occurrence of vibrations and percussions (often, rarely), and the estimated average sound isolation values in dwellings (best, ordinary). Data will be collected from major and megacities.

The AMIS Global Air Quality Information Exchange system is planned as a component of a Global Air Quality Partnership, which can be visualized as an information turntable provided and used by members (see figure on next page). It is envisaged that all members will provide and have access to this information.

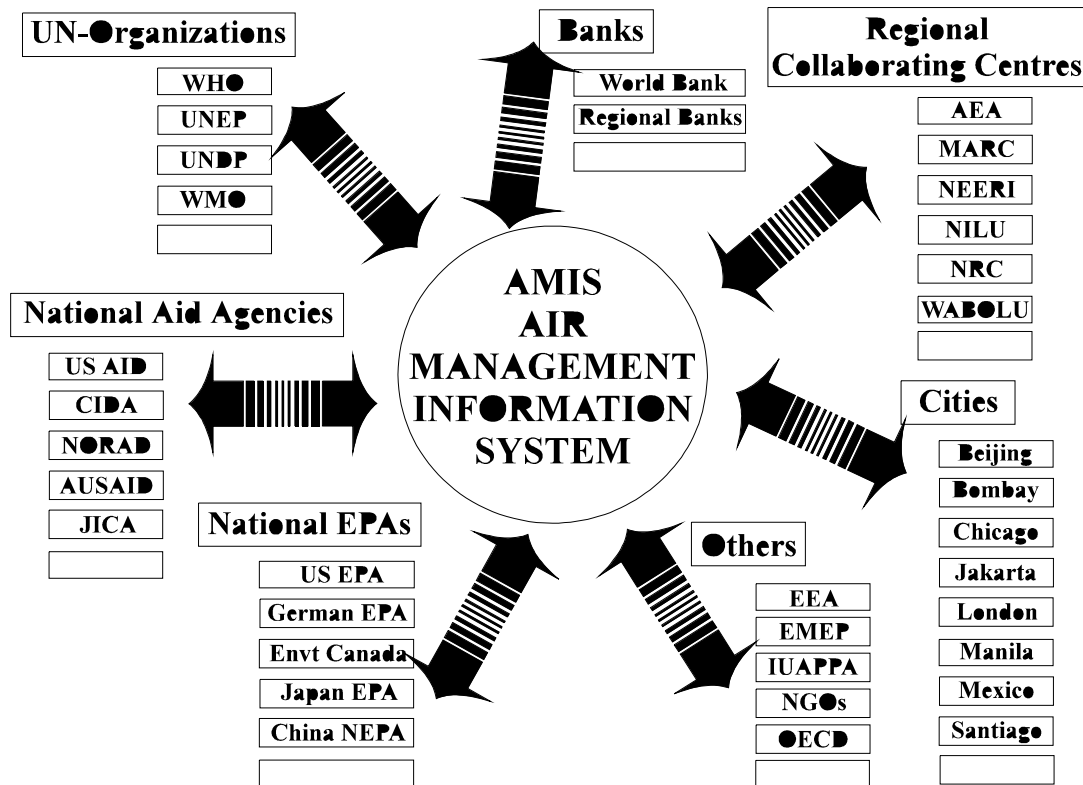
- Acting as an information broker between countries;
- Providing and distributing technical documents on air quality monitoring and management;
- Publishing and distributing Annual Trend Reviews on air pollutant concentrations;
- Providing training courses on air quality monitoring and management;
- Running Regional Collaborative Centres for data transfer, training, and implementing twinning projects.

- WHO community noise guidelines and country standards;
- Emissions of major and megacities;
- References to other air quality databases;
- AMIS participants;
- Monitoring device manufacturers;
- Training institutions;
- Use and accessibility of dispersion models
- Indoor air pollution levels in urban and rural areas;
- Noise pollution levels in major and megacities.
- Air quality management capabilities and procedures of cities;
- Control actions and their costs;
- Adverse effects of air pollution on health and their costs.

The Global Air Quality Partnership

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Data collection (2): Community Noise Guidelines

The aim of these guidelines is to protect public health from adverse effects of noise, provide background information for making risk management decisions, and give guidance in setting national noise standards and action plans. In the recommendations, which have been published¹¹, hearing impairment is given as a critical effect in the environment of concert halls, discos, outdoor concerts and wearing headphones where the Leq is greater than 100 dBA on a time base of 4 hours. Hearing deficits are given as a critical effect for impulsive sounds at greater than L_{max} 140 dBA. These guidelines are due to be revised and updated by WHO in 1999.

¹¹ Berglund B., Lindvall T; Stockholm, 1995.

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7.2 Research opportunities

- More investigators and investigations for epidemiology, pathogenesis, & patho-physiology of noise-induced hearing loss

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More research is needed in the epidemiology¹², pathogenesis, and pathophysiology of noise-induced hearing loss and on new methods to prevent, manage & treat it. There also needs to be more collaboration between developed and developing countries, for example to conduct longitudinal studies. Research and development needs that were proposed and discussed during the meeting are given in box 9.

The US National Institute on Deafness and Other Communication Disorders (NIDCD), as part of its mission, conducts and supports research on noise-induced hearing loss. Some examples of research studies conducted or supported by the NIDCD have shown that heat shock proteins in response to moderate sound levels condition the ear to withstand effects of loud noise although there is individual variability; evidence that the stapedial acoustic reflex gives protection from low-frequency intense sounds to the inner ear; reduced cochlear blood flow and localized ischaemia occurs during noise exposure with effects on the TTS.

Some of the current research being supported by the NIDCD includes a study in Europe (NIDCD-Nord Trondelag Study) of 50,000 adults aged over 20 years to estimate genetic & environmental effects including noise on hearing. Another study (NHANES IV) will investigate in 1999-2004 using noise exposure history and audiometry a randomly-selected population of 11,000 in the USA. The NIDCD has contributed to the National Strategic Research Plan (NSRP); the section on Hearing and Hearing Impairment, updated in 1996, includes many of the items listed in box 9.

- how noise causes hearing loss
 - site of insult in the auditory system
 - molecular mechanisms,
- Interactions between noise exposure and other agents (eg organic solvents, ototoxic drugs, vibration)
- How to improve screening for early detection in at-risk populations
- Whether hearing impairment progression can be reversed through early detection
- How to predict permanent hearing loss in relation to temporary threshold shifts
- How to improve diagnostic and protective measures
- Safe levels for occupational noise exposure
- Better devices for ear protection
- New strategies to raise awareness of the value of hearing and causes of hearing loss
- Whether interventions can reduce hearing loss from noise (eg magnesium, melanin, antioxidants, prior low-level noise exposure)
- The costs of noise-induced hearing loss
- More studies of leisure-time noise

¹² See section 3 and boxes 2 & 3 for further information on epidemiological research and data needs

8 CONCLUSIONS AND RECOMMENDATIONS

Exposure to excessive noise is the major avoidable cause of permanent hearing impairment worldwide. In a developed country, exposure to excessive noise is at least partially the cause in more than one-third of those in the population who have hearing impairment. In many countries, NIHL is the most prevalent irreversible industrial disease, and noise is the biggest compensatable occupational hazard. Furthermore, in developing countries, occupational noise and urban, environmental noise are increasing risk factors for hearing impairment. Exposure to excessive noise is also of concern because it is associated with distressing conditions such as tinnitus.

A meeting of invited experts from developed and developing countries was convened by the Programme for the Prevention of Deafness and Hearing Impairment (PDH) at WHO, Geneva from 28-30 October in order to address the problems of NIHL and to seek methods for its prevention, especially in relation to developing countries.

RECOMMENDATIONS

- 1 **Definition.** For survey purposes¹³, a hearing impairment can be attributed to noise according to the following criteria:-
 - (1) Noise history. Where there is material noise exposure, that is 100 dB (NI) [noise immission] or 83 dBA $L_{\text{aeq},40}$ [40 hours per week equivalent continuous noise level] for a 50 year lifetime (equivalent exposure).
 - (2) Audiometric criteria (these are applicable in addition to the noise history criteria).
 - (i) The impairment is predominantly sensorineural (air-bone gap average at 1, 2 & 4 kHz is less than 15dB; tympanometry could also be used to exclude middle-ear disorders)
 - (ii) The impairment is not unilateral (asymmetry average at 1, 2 & 4 kHz less than 15dB).
 - (iii) Additional indication of a noise attribution is found if the 0.5 kHz threshold is less than 50dBHL, and if the difference between the high frequency threshold average of 3, 4, 6 kHz and the low frequency threshold average of 0.5, 1, 2 kHz is equal or greater than 15 dB in those aged under 50 years.
2. **National Programmes.** The prevention of NIHL requires an integrated, multi-sectoral approach, addressing general educational needs as well as particular risk situations. National programmes, integrated with Primary Health Care (PHC), should be established

¹³This definition is intended for use in epidemiological surveys in order to estimate the proportion of the prevalence of hearing impairment that is attributable to noise. It is not intended to be used in circumstances where a differential diagnosis is being made or compensation is being determined.

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or strengthened in all countries.

It is recommended that, to deal more effectively with NIHL, key information and messages on prevention and control of harmful noise exposure and hearing conservation should be widely disseminated including to PHC workers, for their advocacy in the local community.

3. Awareness. There is a great need for creating more public awareness of the harmful effects of noise on hearing and the prevention of NIHL.

It is recommended that this matter should be included in school and all health educational programmes, and in specific advocacy campaigns. In addition to knowledge about the negative consequences of harmful noise, a positive image of hearing should be promoted, including its contribution to the daily quality of life.

4. Occupational Noise. This is still a major problem particularly in developing countries. Not all countries have legislation or are sufficiently enforcing it. Protectors, where available, are not always acceptable to the workforce.

It is recommended that the source of the noise should be reduced where possible. Legislation should be introduced in all countries and an effective inspectorate developed. Hearing conservation programmes, including audiometry and workers' education, should be introduced wherever needed. Technological advancements should be disseminated to developing countries.

5. Training. The development of hearing conservation programmes are limited by the lack of trained personnel to carry out noise surveys and audiometric testing.

It is recommended that developing countries identify cadres of personnel for training, and develop training programmes, and sources of funding.

6. Community Noise. There has been rapid urbanization in many developing countries which is continuing, and which has resulted in high levels of traffic noise in the cities. Objective measurements often show noise levels which are likely to cause hearing impairment.

It is recommended that measures be taken to reduce levels of traffic noise, for example, by devising and enforcing regulations, promoting proper use of silencers, effective land use planning, and using quieter technology wherever possible.

7. Firearms. There is overwhelming evidence that firearms are a source of noise-induced hearing impairment.

It is recommended that people who fire a weapon should be made aware of the danger to themselves and others and of the need for proper ear protection.

8. Socio-Economic Impact. There is insufficient information on the economic costs of NIHL so that it is difficult to establish the priority for prevention.

It is recommended that data be gathered to enable the social and economic consequences of NIHL to be determined.

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9. Leisure. There are a number of different sources of noise during leisure activities which imply a risk for hearing impairment. Leisure noise is a problem in adults and children.

It is recommended that high-noise leisure pursuits should be limited and toys marked as sound safe.

10. Non-Governmental Organizations (NGOs). Developing countries face severe constraints in their ability to deal with the problem of NIHL. There is a need to develop civil and political commitments to achieving effective prevention of NIHL.

It is recommended that efforts for collaboration be made between WHO and its member states with concerned NGOs and other interested parties in order to support prevention at the community level.

11. Epidemiological Data. There is a serious shortage of accurate epidemiological information relating to NIHL especially in developing countries.

It is recommended that

- representative surveys be conducted of the prevalence of significant NIHL in less developed countries
- high quality longitudinal data be gathered to better understand the development and progression of NIHL.
- effective screening methods be developed for early identification of and intervention against NIHL.

12. Research Priorities. There is considerable ignorance about the pathogenic mechanisms of noise-induced hearing loss and effective means for its prevention.

It is recommended that priority should be given to research on the following subjects:

- Mechanical, metabolic and molecular mechanisms of NIHL;
- Investigation of low cost medications for prevention;
- Engineering research on technical measures for noise abatement and improving hearing protectors;
- Studies on the risk factors for NIHL including individual susceptibility to noise damage.
- studies on the interaction of other toxic agents with noise

13. Research collaboration. There is a great need for more basic and applied research in the field of prevention of NIHL.

It is recommended to establish effective networking for communication and collaboration between interested institutions in developed and developing countries in order to facilitate and expand basic and applied research. Twinning of institutions, exchange of faculty personnel, and joint research projects could, amongst others, be useful approaches to promote such research collaboration.

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ANNEX 1: AGENDA

Opening of the meeting by Dr R.H. Henderson, Assistant Director-General, WHO.

- 1 EXCESSIVE NOISE AS A GLOBAL CAUSE OF HEARING IMPAIRMENT** *[presentation by Dr A.W. Smith, WHO]*
- 2 PATHOGENESIS OF NOISE-INDUCED HEARING LOSS** *[presentation by Professor P. Alberti, Canada]*
- 3 EPIDEMIOLOGY OF NOISE-INDUCED HEARING LOSS.** *[presentation by Dr A. Davis, UK]*
- 4 REPORTS FROM REGIONS**
 - Africa Region. *[Presentation by Dr G. Amedofu, Ghana]*
 - Americas Region. *[Presentation by Dr J. Franks, USA and Dr T.C. Morata, Sweden]*
 - Eastern Mediterranean Region. *[Presentation by Prof S. Soliman, Egypt and Prof S. Zaidi, Pakistan]*
 - European Region. *[Presentation by Dr D. Prasher, UK]*
 - South East Asia Region. *[Presentation by Dr S. Ogale, India and Dr S. Prasansuk, Thailand]*
 - Western Pacific Region. *[Presentation by Prof Y. Nakai, Japan]*
- 5 PREVENTION AND MANAGEMENT WITHIN PRIMARY HEALTH CARE**
 - Introduction *[presentation by Dr B. Thylefors, WHO]*
 - Individual strategies *[presentation by Dr William Clark, USA]*
 - Environmental strategies *[presentation by Prof Alf Axelsson, Sweden]*
 - Occupational strategies *[presentation by Thais C. Morata, Sweden]*
 - Detection & Monitoring *[Presentation by Dr J. Franks, USA]*
- 6 DEVELOPMENT OF A NATIONAL PLAN FOR PREVENTION OF NOISE-INDUCED HEARING LOSS**
 - Perspective from a developing country- Pakistan *[Presentation by Prof S. Zaidi]*
 - Perspective from a developing country - Kenya *[Presentation by Dr M D'Cruz]*
 - Perspective from a developed country - Finland *[Presentation by Ms M-L. Rontu, Finland]*
 - Legislation and Compensation *[Presentation by Dr I. Mackenzie, UK]*
- 7 PRESENT AND FUTURE NEEDS**
 - Data Collection: The Air Management Information System (AMIS): Noise level database *[Presentation by Dr D. Schwela, WHO]*
 - Research opportunities *[Presentation by Mr H. Hoffman, USA]*
 - Media opportunities *[Presentation by Mr I. Rozoff, WHO]*
- 8 CONCLUSIONS AND RECOMMENDATIONS**

ANNEX 2: LIST OF PARTICIPANTS

Prof Peter W. Alberti
General Secretary
International Federation of
Otolaryngological Societies (IFOS)
200 Elizabeth Street
Toronto, Ontario
Canada M5G 2C4
Tel: +1 416 340 4190
Fax: +1 416 340 4209
email: alberti@gpu.utcc.utoronto.ca

Dr G.K. Amedofu
School of Medical Sciences
University of Science and Technology
Kumasi, Ghana
Tel: +233-51-23298
Fax: +233-51-25306
goldlink@ghana.com

Prof Alf Axelsson
Sahlgren's Hospital
Lindholmen Development Hearing
Research Laboratory
P.O. Box 8417
40275 Göteborg
Sweden
Tel: +31 507 000
Fax: +31 515 313

Dr G.R. Bock
Deputy Director
The CIBA Foundation
41 Portland Place
London W1N 4BN, UK
Tel: +44 171 636 9456
Fax: +44 171 436 2840
email: g bock@novartis.org.uk

Dr William Clark
Director of Professional Services
Central Institute for the Deaf
Professor and Chairman
Dept of speech and Hearing
Washington University
818 S. Euclid

St Louis, Mo 63110, USA
Tel: +1 314 977 0000
Fax: +1 314 977 0023
email: clark@CID.wustl.edu

Dr Armand Dancer
French-German Research Institute of
Saint-Louis
5 Rue Du Gen
Cassagnau BP 34
68301 Saint-Louis Cedex
France
Tel: +33 3 89 69 50 94
Fax: +33 3 89 69 50 02
email: dancer@nucleus.fr

Professor Adrian Davis
Head of Epidemiology, Public Health &
Clinical Section
MRC Institute of Hearing Research
University Park
Nottingham NG72RD, UK
Tel: +44 (0) 115 922 3431
Fax: +44 (0) 115 951 8503
email: acd@ihr.mrc.ac.uk

Dr M.J. D'Cruz
Kenya Ear Foundation
P.O. Box 43774
Nairobi, Kenya
Tel: +254 2 26253
Fax: +254 2 17290

Dr John R. Franks
Chief, Bioacoustics & Occupational
Vibration Section
Physical Agents Effects Branch
Division of Biomedical and Behavioural
Science, NIOSH/CDC
4676 Columbia Parkway, C-27
Cincinnati, Ohio 45226-1998, USA
Tel: +1-513-533-8151
Fax: +1 513 533 8139 or 8510
email: jrf3@cdc.gov

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Professor R. Hinchcliffe
13 South Hill Close
Hitchin, Herts. S64 9HR, UK
Tel: +44 1 462 454 394
Fax: +44 1 462 454 394

Mr Howard Hoffmann
Chief, Epidemiology, Statistics & Data
System Branch
National Institute on Deafness and Other
Communication Disorders (NIDCD)
EPS Room 430D,
6120 Executive Boulevard MSC 7180
Bethesda, MD 20892-7180
Tel: +1 301 402 1843
Fax: +1 301 402 0390
email: HoffmannH@ms.nidcd.nih.gov

Dr Ian J. Mackenzie
Hearing Impairment Research Group
International Health Division
Pembroke Place
Liverpool School of Tropical Medicine
Liverpool L3 5QA, UK
Tel: +44 151 708 9393
Fax: +44 151 707 1702
email: MACKENZIE@fs1.ed.man.ac.uk

Thais C. Morata
Research Audiologist
National Institute for Working Life
Arbmed Ekelungsvagen 16,
S-171-84 Solna, Sweden
Tel: +46 8 730 9542
Fax: +46 8 820 556
email: Thais.Morata-@niwl.se

Dr H. Nabulsi
Coordinator IMPACT
c/o World Health Organization
20, Avenue Appia
CH-1211, Geneva 27
Switzerland
Tel: +4122 791-3733
Fax: +4122 791 0746

Professor Yoshiaki Nakai
Chairman, Noise Induced Hearing
Disorders Standing Committee, IFOS

Professor and Chairman, Osaka City
University Medical School,
Department of Otolaryngology,
1-5-7 Asahimachi, Abeno-Ku,
Osaka, 545, Japan
Tel: +81 6645 2180
Fax: +81 6646 0515

Dr Valerie Newton
Professor of Audiological Medicine
Centre for Audiology, Education of the
Deaf and Speech Pathology
University of Manchester
Oxford Road
Manchester M13 9PL, UK
Tel: +44 161 275 3370
Fax: +44 161 275 3373
email: NEWTON@fs1.ed.man.ac.uk

Dr Sukhakar Ogale
Professor and Head, Department of ENT
G.S. Medical College & K.E.M. Hospital
Parel, Mumbai-400012
India
Tel: + 91 22 413 6051
Fax: + 9122 414 5056

Dr Suchitra Prasansuk
Director, Otological Center: Bangkok Unit
Department of Otolaryngology
Faculty of medicine, Siriraj Hospital
Mahidol University
Bangkok 10700, Thailand
Tel: +66 2 411 3254
Fax: +66 2 465 4050
email: sispa@mahidol.ac.th

Dr Deepak Prasher
Institute of Laryngology & Otology
University College London
330 Gray's Inn Road
London WC1X 8EE, UK
Tel: +44 171 915 1527
Fax: +44 171 278 8041
email: d.prasher@ucl.ac.uk

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Dr Mirja-Liisa Rontu
Secretary-General
International Federation of Hard of
Hearing (Europe)
The Finnish Federation of Hard of Hearing
Ilkantie 4
00400 Helsinki, Finland
Tel: +358 9 580 3310
Fax + 358 9 580 3331

Prof Salah M. Soliman
Professor of Audiology
College of Medicine
Ain Shams U. - 10 Saray El-Gezira St
Zamalek - Cairo 11211, Egypt
Tel: +202 340 2247
Fax: +202 342 32 32

Prof Jun-Ichi Suzuki
President, Hearing International
Professor and Chairman
Teikyo University School of Medicine
Kaga 2-11-1, Itabshi-Ku
Tokyo 173, Japan
Tel: +81 33 964 1211
Fax +81 33 964 0659
email: jis@med.teikyo-u.ac.jp

Professor Syed S.H. Zaidi
Professor & Head of Department
Jinnah Postgraduate Medical Centre
Medicon Hospital
13-c/4, Federal B Area
Karachi, Pakistan
Tel: +92 21 634 2999
Fax: +92 21 568-9258 or +92 21 671 264

Dr R.H. Henderson, ADG

Mrs Berenice Goelzer
Occupational Health (OCH)

Dr E. Pupulin
Chief, Rehabilitation (RHB)

Dr D.H. Schwela
Urban Environmental Health (UEH)

Dr A.W. Smith
Medical Officer, Prevention of Deafness
and Hearing Impairment (PDH)

Dr B. Thylefors, Director
Prevention of Blindness
and Deafness (PBD)

WHO Secretariat

ANNEX 3: SPEECH BY DR R.H. HENDERSON, ASSISTANT DIRECTOR-GENERAL, WHO

Friends and colleagues,

It is a great pleasure for me to welcome all of you to this *Informal Consultation on the Prevention of Noise-induced Hearing Loss*.

This meeting is the third in a series on "STRATEGIES FOR PREVENTION" that are organised by the WHO Programme for the Prevention of Blindness and Deafness. These meetings deal with major causes of deafness and hearing impairment that constitute public health problems. Prevention of deafness and hearing impairment from **ototoxic drugs**, and from **chronic otitis media** have already been addressed. It is therefore appropriate that this meeting has been convened to consider noise-induced hearing loss, another major cause, since this condition should be particularly amenable to prevention. Although other WHO Programmes have addressed the problem of noise in the occupational and community settings, this is the first approach to be concerned solely with **noise-induced hearing loss**.

Noise-induced hearing loss is insidious, permanent, and irreparable and causes communication interference that can substantially affect the quality of life. In a developed country, exposure to excessive noise is at least partially the cause in more than one-third of those in the population who have hearing loss. Noise-induced hearing loss is the most prevalent irreversible industrial disease and noise is the biggest compensatable occupational hazard. In the developed world, exposure to social noise is increasing, and may be a particular hazard for young people. In developing countries, urban environmental noise and occupational noise are escalating hazards for hearing loss and, in these countries, there are fewer controls on noise and less opportunities and activities for prevention of its effects. The problem is being augmented by population ageing, whereby presbycusis is substantially increasing the worldwide total of hearing disability. However, there is still a serious lack of credible, population-based data, especially for developing countries, that would enable us to assess accurately the size of these problems.

A key task of WHO programmes is to provide technical advice and support to Member States and other interested parties for the development and implementation of health care programmes. For the field of noise-induced hearing loss, your help is needed to address key questions that will assist us in this task. First of all, what is the state of knowledge in this field and how can we improve it? Why is the burden of disability caused by this condition persisting, and in some countries worsening? Are appropriate and cost-effective interventions available for prevention, particularly for developing countries? How best should these be implemented?

We hope that this meeting will identify the key practical and affordable measures that can be implemented to prevent the problem of noise-induced hearing loss, especially in vocational and societal settings. With these measures, we will be better able to assist countries to make a significant reduction in the burden of deafness and hearing impairment in their populations.

Thank you very much.

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