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LESS NOISY CITIES

Shelly Khanna Chadha
MS (Otolaryngology)

*Professor of Ear, Nose and Throat
Maulana Azad Medical College
New Delhi, India 110002*

Email: drshellychadha@rediffmail.com

Bulantrisna Djelantik
MS (Otolaryngology)

*President, Society for Sound Hearing
Jl Segara Ayu 3 Sanur
Denpasar Bali, Indonesia*

Email: btrisnya@gmail.com

Arun K Agarwal
MS (Otolaryngology)

*Director and Professor of Ear,
Nose and Throat
Dean, Maulana Azad
Medical College
New Delhi, India 110002*

Email: dragarwal82@rediffmail.com

'Megacities' and 'Less Noisy Cities'

As the world moves forward in the 21st century, there is increasing urbanisation with its consequent explosion of urban population leading to the development of megacities. 'Megacities' is a term introduced by the United Nations, to describe cities with at least 10 million inhabitants. It is expected that by the year 2015, there will be 33 such megacities in the world. Twenty seven of these will be in developing countries. With greater development comes greater problems and environmental ills. Due to increasing industrialisation and mechanisation, the problem of 'Noise' has become a serious issue in such cities and the menace is likely to grow, if not checked.

With this in mind, the *Society for Sound Hearing* has developed the concept of 'Less Noisy Cities'. This is a comprehensive programme, looking at various aspects of noise, its control and reduction in the urban context.

The *Aim* of such a programme is:

- To reduce noise exposure of the population living in megacities and to control its possible adverse effects.



'Noisy' truck in Delhi!

Photo: Ashwin Chadha

The *Strategies* for this include:

- Identifying all stakeholders - the legislators, administrators, perpetrators (those who cause the problem) and residents
- Focus on 'Awareness Building' as the main component of the programme

CONTENTS

Community Ear and Hearing Health 2010; 7: 1-12

Issue No.10

LEAD ARTICLES

Less Noisy Cities	Shelly Khanna Chadha, Bulantrisna Djelantik, Arun K Agarwal	1
How Much Hearing Loss is Caused by Noise?	Robert A Dobie	3
Hearing Protectors	Alberto Behar	4
Pharmacological Protection of NIHL	Donald Henderson, Chiemi Tanaka	7

BOOK REVIEW

Digital Hearing Aids (Reviewed by Ron Brouillette)	James M Kates	9
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ABSTRACTS

10

Less Noisy Cities

- Promoting community empowerment through proper strategies
- Developing stricter laws, if possible
- Ensuring better implementation of existing laws
- Developing innovative strategies for the above.

The **Activities** that are advocated in this regard include:

1. **Anti-Noise Cell.*** Create an Anti-Noise Cell in the city that will be in a position to:

- Receive complaints related to noise
- Decide the validity of these complaints
- Be empowered to take action against the offenders.

The presence of this Cell has to be publicised widely, so that people know where to complain about noise related problems.

**A Unit/ 'Action Team' that is created for the purpose of monitoring and responding to Noise-related queries and complaints.*

An effective and efficient Cell is the keystone to the success of this venture.

The Cell must have representation which includes environmental and medical experts as well as law makers, industrial representatives and administrators. The complaints made have to be verified properly. Genuine problems must be addressed at the earliest, within the framework of the local laws, in order to ensure effectiveness of the Cell.

2. **Awareness Campaigns.** As prevention is the main component, it is important to create awareness about the harmful effects of noise on our body. Various modalities for awareness creation can be:

- Campaign through Advertisements on city buses, trains or trams
- Television and Radio Programmes regarding the ill-effects of noise
- Write stories for Newspapers and Magazines regarding various aspects of noise
- Speak to School Students, as it is essential to educate the younger generation regarding this aspect so that they can develop responsible behaviour patterns
- Speak to Civic Groups and Resident Associations, so that they know about the existing

legislation in relation to noise control, their rights and the course of action available to them in case of any violation

- Produce and distribute Brochures and put up Posters at public places including hospitals, airports, stations
- Locate and promote a Celebrity Spokesperson for the anti-noise cause.

3. **Noise Conservation Programmes.**

Make the implementation of Noise Conservation Programmes a requirement in all factories and industrial houses. Besides industry, these programmes should also be implemented for other high risk groups such as:

- Traffic policemen
- Workers at busy traffic intersections
- DJs at discotheques/ bars/ restaurants
- Workers in Call Centres (who might be at risk)
- Airport staff.

4. **Strict Implementation of Existing Legislation.** Noise control legislation can only be introduced in concurrence with the law-making and enforcing agencies.

5. **Recommended New Legislation.**

- Monitoring and regulation of noise levels in various urban areas including:
 1. Cinema halls
 2. Restaurants and Bars
 3. Discotheques
 4. Malls

This is essential, as these places are often noisy and habitual or prolonged exposure to this is a potential cause of auditory and extra-auditory effects of noise.

- Noise Labels: Many items of daily use such as household equipment, children's toys, firecrackers and recreational equipment, such as I-Pods, Walkmans, etc. emit high levels of noise. Noise labels should be on each of these items giving the levels of noise that they emit. Wherever the levels are hazardous, they should be accompanied by a warning

regarding the potential side effects and the recommended duration of maximum exposure.

This legislation will serve the dual purpose of ensuring compliance with the recommendations and creation of awareness amongst the users regarding the fact that noise can be harmful.

6. **Guidance and Guidelines.** Provide guidance and guidelines to the city developers regarding development of new roads and housing, in a manner that is environment friendly and makes use of noise absorbent material and various natural and artificial noise barriers. This should be done in consultation with the local Ministry of the Environment. Guidelines developed should be valid, practical and affordable.

7. **Anti-Noise Groups.** Create active Anti-Noise Groups in Schools, Colleges and in Communities.

8. **'Noisy Dozen' Awards.** Present awards to major noise polluters in the city. These will be awards given to those individuals or industrial houses, etc., who are considered to be the major noise polluters within the city. The awards will be a means of bringing them into the public eye.

9. **Noise Awareness Day.** Promote Noise Awareness Day in the city. On this day, various activities can be held in different parts of the city including:

- Advertisements in the papers and hoardings
- Essay or drawing competitions
- Public lectures.

10. Promote an **Annual Noise Free Week.**

These activities will need to be undertaken in a step-by-step manner and in consultation with the policy makers of the city, in order to ensure the political, financial, administrative and legal commitment of the political framework of the city.

Practical Implementation of the Project

The Project entitled 'Less Noisy Delhi' was presented to the Government of New Delhi, the capital city of India. The Government has approved, in principle, the implementation of the Project. A pre-Project survey to assess the impact of noise on the residents of Delhi is already being carried out.

However, certain problems encountered and foreseen include:

- Slow movement of Government activities due to lengthy and time consuming processes
- Political activities, such as elections, that often overshadow the technical and non priority programmes
- Difficulty in involvement of industry. This has to be overcome by involvement of agencies such as the Factories Inspectorate (which, in Delhi, must certify all factories and carry out regular inspections), as well as local environmental agencies (Delhi Pollution Control Committee in Delhi)
- Overburdening of law enforcement agencies with many matters in a city such as Delhi (where large number of VIPs live) - a major

- factor affecting the implementation of legislation. These agencies have to be convinced through tactful advocacy, in order to involve them in the programme. Without their commitment, the programme is bound to be a failure
- Certain components of the programme are difficult to implement and are not agreed upon, such as the noise labels on products
- Certain components are easier to implement due to their appeal to the general public, such as a Noise Free Day. Recently, 1st January was observed as a 'No Honking Day' in Delhi.

Positive aspects and outcomes include:

- Mobilisation of political will
- The school health system in Delhi

is well established and provides a suitable channel for involvement of the younger generation. There are numerous Residents' Welfare Associations in Delhi, which are active and motivated. We are seeking their help in local implementation of noise control and awareness generation.

The Society for Sound Hearing is a South East Asian initiative that is working for Prevention of Hearing Loss in the various countries of the region. 'Sound Hearing 2030' is the programme launched by this Society. There will be two further articles on Sound Hearing 2030 in Issues 11 and 12.



HOW MUCH HEARING LOSS IS CAUSED BY NOISE?

Robert A Dobie MD

*Clinical Professor
University of California at Davis
Adjunct Professor
University of Texas School of Public Health
USA*

Email: radobie@ucdavis.edu

Everyone knows that noise causes hearing loss in our modern societies, but how much? This simple question is actually quite hard to answer, until we make two important choices.

First: what do we want to measure?

Probably not the number of people with hearing aids, since most hearing-impaired people don't have them. Self-report of hearing difficulty is another possibility, but young people tend to exaggerate their hearing problems and older people minimise them.

Pure tone audiograms have been carried out on representative samples of populations in the USA and many other countries for decades, and probably represent the best option. The audiogram consists of thresholds (the softest audible sounds, measured in decibels, or dB) for each ear, for each of several frequencies (measured in Hertz, or Hz). These frequencies range from 250 Hz (middle C on the piano) to



Hearing protection with M-16 rifle fire

Photo: US Department of Defense

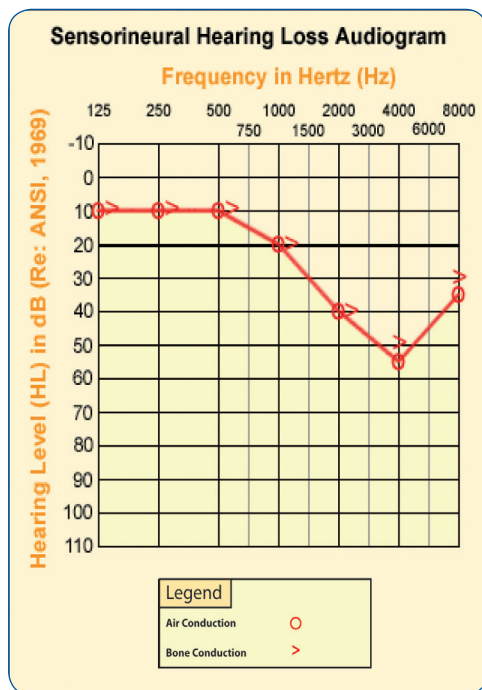
8000 Hz (an octave above the highest note on the piano). The most important frequency range for speech understanding is from about 500 Hz to about 3000 Hz. When the average of the better ear's thresholds in this range exceeds 25 dB, a person usually has substantial difficulty with hearing. So the simplest answer to the measurement question might be to count the number of such people (a more complicated approach gives more weight to people with more severe hearing loss, but yields very similar estimates of the relative impact of noise).

Second: how do we know which of these people have noise-induced hearing loss (NIHL)?

Older people (especially men) are frequently hearing-impaired, without any apparent cause, and there are many other causes of hearing loss (infections, tumours, etc.). There is no blood test or X-ray that can distinguish NIHL from age-related hearing loss (ARHL), and the audiometric features of these two common disorders are quite similar. A history of noise exposure helps, but these

Hearing Loss Caused by Noise

data are usually unavailable or scanty in population-based audiometric surveys. The approach chosen by a World Health Organization (WHO) team (Nelson et al, 2005) and by me (Dobie, 2008) was to construct computer models that incorporated data about the degree of hearing loss caused by different levels of noise exposure (measured in 'A-weighted decibels' or dBA), combined with surveys of the prevalence of these different levels of noise exposure.



been better, but not completely normal. Second, NIHL is dose-related; a career spent in a 95 dBA workplace causes much more incremental loss than a career at 85 dBA. For example, an international standard (ISO-1999) allows the comparison of the percentage of hearing-impaired 60-year-old men in the general population of the USA (28%) to the percentages for men of the same age who have been exposed for 40 years at 85 dBA (31%) or 95 dBA (46%).

My own models assumed that, at any given time, there were about 12 million people with current hazardous occupational noise exposure in the USA. This included the manufacturing, utilities, transportation, mining, construction, agriculture, and military sectors. I assumed that this number was constant over the last several decades, and that no one ever used hearing protection devices. Including those whose noise-exposed careers have ended, the models assume that there are about 26 million American adults with current or past hazardous occupational exposure.



Tractor noise

Photo: US Department of Agriculture

When occupational noise was included, the model estimated that 27.3 million American adults had speech-frequency losses (averaged across 500, 1000, 2000, and 3000 Hz) exceeding 25 dB. When it was excluded (by assuming that all adults had always had quiet jobs), there would still have been 24.7 million such people, suggesting that occupational noise was responsible for about 10% of the overall hearing loss problem.

These models differ in some details, but all are based on two fundamental facts. First, with the exception of the very young, most people with NIHL also have some ARHL. If they had not been noise-exposed, their hearing would have

HEARING PROTECTORS: QUESTIONS AND ANSWERS

Alberto Behar PEng CIH

Adjunct Assistant Professor
University of Toronto
45 Meadowcliffe Drive
Scarborough, Ontario M1M 2XB
Canada

Email: behar@sympatico.ca

Alberto Behar is an Acoustical Engineer, and a Board Certified Industrial Hygienist, specialising in hearing conservation and noise control.

Introduction

All of us are familiar with noise: loud or quiet, pleasant or unpleasant, it is all around us. It is present during our activities in different ways: as speech, songs, music, car horns, engine noise, * etc. As such, it elicits different feelings, making us feel happy, sad, annoyed or ecstatic.

Most of the time, noise produces psychological effects that last while noise is present and disappears when quiet returns. However, when the noise is loud and persists over long periods of time, it can affect our hearing. This is a fact

that has been known for many, many years. For example, at the beginning of the Industrial Revolution, the so-called 'boiler makers' deafness' was not only known but was also a documented problem.

Noise is measured as 'noise level', in decibels (dB) that span between 0 and 120 dB. Many industries are known to gener-

* By definition, sound is a physical cause that elicits the sensation of hearing. Noise is unwanted sound and most of the time is unpleasant.

Hearing Protectors

ate loud noises that may cause loss of hearing.* Some of the major industries and offenders are mining, construction, metal, textile and paper industries.

Hearing Loss due to Noise

Our ear is a very complex system, where the sound pressure (the noise) is transformed into electrical (nerve) signals that are sent to our brain. The brain, in turn, 'interprets' those signals and allows us to recognise what the signal is about, whether it is speech, an alarm signal, music or much beside.

** There is a difference between 'deafness' and 'hearing loss'. The first refers to a total loss of hearing, while the second applies to situations where the subject can still hear, but with difficulties.*

The transformation is performed in the cochlea, or inner ear, by some 20,000 hair cells stimulating nerve endings (hair cells). Exposures to high noise levels for long periods of time (generally years) damages these tiny cells in such a way that they are unable to perform the transformation mentioned above. The net result is that the electrical signals (nerve impulses) become smaller and smaller and the person cannot hear faint sounds. This loss of hearing is selective – at first it affects the high frequencies, such as those from a telephone ring or the consonants in our speech. As a result, the person can hear, but has difficulty in understanding. With longer exposures, the entire range of hearing is affected.

Some people claim that they 'get used to noise'. However, the fact is that they are not affected by the noise, because they are not able to hear it any more. The tragic consequence of the loss of hearing is that there is no cure. Even getting away from the noise, such as working in a quiet environment, does not help recover the hearing. Whatever is lost is lost forever!

Hearing acuity is measured using devices known as audiometers and the measurement procedure is known as audiometry. Basically, it consists of measuring the threshold of hearing** at different frequencies - generally from 500 Hz to 8,000 Hz.

***This is the feeblest sound that the person perceives at a given frequency.*

Hearing loss from noise exposure is generally bilateral (affecting both ears)

and it is located mainly around the frequency of 4000 Hz.

Noise is not the only cause of hearing loss. Age is another factor, as is the use of ototoxic drugs, exposure to some solvents, etc.

Reduction of the Noise Hazard

The only way of reducing the risk of hearing loss is by reducing the noise energy entering the ear. This is achieved by lowering the noise level to which a person is exposed. The safe limit is universally accepted as below 85 dBA.*** There are two recognised ways of obtaining this goal.

The first is to reduce noise levels at the source, using **engineering noise controls**. This involves application of devices such as mufflers, silencers, barriers, enclosures and acoustical materials. Their use either reduces the generation of the acoustical energy or simply impedes the energy that is propagated and affects the hearing of the exposed people. Use of engineering noise controls is by far the preferred way of dealing with the hazard, since this does not require action by the exposed people.

****dBA is the unit of sound pressure level measured using the 'A' weighting. In practice, the sound level meter (the instrument to measure noise levels) can be set to measure directly in dBA.*

Good as these controls are, sometimes it is not practical or it is too expensive to

implement them. In that case, the only other way of reducing the risk of hearing loss is by using hearing protectors, devices worn by the person exposed to the noise.

Hearing Protection Devices

There is nothing more common in a noisy workplace than a **hearing protector**. Since noise is the most prevalent occupational hazard in the industry, they are found almost everywhere, and are known to almost every member of the work force. Plugs, muffs, semi-inserts, pre-molded, sponge-like, active and noise-cancelling, protectors come in different shapes, sizes and ways of operating. The only property that they have in common is that they are all intended to reduce the sound pressure that penetrates the ear of the wearer, and, by doing so, prevent the damage to the hearing of the exposed personnel.

Since their objective is so simple, it is surprising that there are so many models and types in the market,**** made by many manufacturers. The variety of protectors greatly exceeds what is found among other personal protective devices, such as hard hats, respirators and safety shoes. This presents a real problem when a decision has to be made regarding which one to choose.

*****The exact number varies at times, but it is estimated to be over 400.*

Basically, there are three types of protectors, with several variations among them. They are: plugs, muffs and semi-inserts (see photographs in Figure 1).



Fig.1: Ear muffs, ear plugs and semi-insert

Hearing Protectors

Depending on the characteristics of the workplace, the task at hand and the existing noise levels, one or other type can be chosen. There are also many individual preferences. Table 1 summarises the principal properties of the plugs and the muffs. The semi-inserts are in general not recommended, since they are more difficult to fit properly and, also, make the wearer feel safe while, in fact, he may not be properly protected.

Ear plugs are devices that are inserted into the ear canal. They have the advantage of being light and, because they are inserted in the ear, they do not interfere with other devices worn on the head (protective or not), such as jewellery, long hair, glasses, etc. They can be made of foam (formable), in which case, they have to be rolled between the fingers until they become like a thin cylinder, before being introduced in the ear canal. Then, they expand filling the crevices of the ear canal. Some are disposable, while some can be re-used. Plugs can also be pre-moulded, generally three-flanged. They do not require any manipulation before introducing them into the ear canal. Finally, there is the category of pre-moulded 'in the ear' plugs, similar to hearing aid ear moulds. An impression is taken of each ear canal and then the plug is manufactured (usually

of silicone) and provided to the user. Attractive as they appear (being individually moulded), they require particular skill by the supplier so that the mould is properly done. If that is not the case, the resulting protection is negligible.

Correct insertion of the plugs is essential to obtain the attenuation of noise they can provide. Therefore, fitting the device becomes a critical operation, since they have to be introduced as deeply as possible to ensure a proper seal.

Ear muffs are devices consisting of two cups made of sound attenuating material, lined with sound absorbers. They are linked by a spring band (made out of metal or plastic) that pushes the cups against the wearer's skull. Cushions installed in each cup ensure a good seal and comfort for the wearer. Muffs have the advantage of being easy to wear, ensuring a good fit and reasonable attenuation of noise. However, they are bulky and heavy to wear over an entire workday. In hot weather they become quite uncomfortable.

There are muffs that can be attached to a hard hat (helmet). Although they are similar to those with the elastic band, movements of the helmet result in

changes in the position of the muffs and, consequently, the seal is broken.

Non-conventional protectors. The above types described (ear plugs, ear muffs) cover most users' requirements. However, there are some workplaces, where the conventional protectors do not solve all problems. That is when a new series of protectors, recently developed, come into place. The following is a brief list, including a short description of the most popular types:

- a) **Amplitude sensitive muffs:** with variable attenuation proportional to the ambient sound level. Ideal for impulse noises, their attenuation is minimal in the absence of noise, but increases with the level of the sound. They are favourites of hunters and others exposed to occasional bursts of high-level impulses.
- b) **Sound restoration muffs:** equipped with electronic circuits, that amplify the external noise, so that the attenuation is reduced, allowing for easy oral communication even with the muffs on. The amplification decreases with the sound level and is equal to zero for levels higher than 85 dB, inside the cup. They are mainly used in locations with variable sound levels, where oral communication is essential.
- c) **Musician plugs (also known as Hi-Fi):** contrary to the conventional plugs (where the attenuation increases with frequency), their attenuation is flat with the frequency. As a result, the sound reaching the ear has the same frequency content as the original sound, without any frequency distortion. They are ideal for musicians, since the music is not distorted. Their attenuation is not very high, something desirable for musicians.
- d) **ANR (Active Noise Reduction) plugs and muffs:** used with communication equipment, they reduce the low frequency noise improving the intelligibility of speech and the quality of music. Used especially by helicopter pilots and tank drivers. Also, airlines provide them to their business travellers for comfort.

Table 1: Comparison of Hearing Protection Properties

Ear Plugs	Ear Muffs
<p>Advantages:</p> <ul style="list-style-type: none"> • Small and easy to be carried • Compatible with other personal protection equipment • Comfortable for long-term wear in hot and/or humid work areas • Comfortable for use in confined work areas • Large variation in individual attenuation. 	<p>Advantages:</p> <ul style="list-style-type: none"> • Less attenuation variability among users • One size fits most head sizes • Easily seen at a distance to assist in the monitoring of their use • Not easily misplaced or lost.
<p>Disadvantages:</p> <ul style="list-style-type: none"> • Fitting plugs is laborious and critical • Hands must be clean when fitting • Easy to lose if misplaced • Difficult to see that they are being used and monitor their usage. 	<p>Disadvantages:</p> <ul style="list-style-type: none"> • Less portable and heavier • Difficult to use with other personal protective equipment • Uncomfortable to use in hot, humid work area • Uncomfortable use in confined work areas • Wearing safety or prescription glasses may result in decreased hearing protection.

Non conventional protectors are much more expensive than the conventional types and should be used only for specific applications.

Caution

Hearing protectors save hearing. There is no doubt about that. However, it has to be kept in mind that there is no substitute for a good Hearing Conservation

Programme when the objective is to preserve the hearing of the exposed worker.

Additional Reading

1. Canadian Center for Occupational Health and Safety (CCOHS) http://ccohs.ca/oshanswers/prevention/ppp/ear_prot.html
2. National Institute for Occupational Safety and Health (NIOSH) <http://www.cdc.gov/niosh/docs/98-126/chap6.html>
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PHARMACOLOGICAL PREVENTION OF NOISE-INDUCED HEARING LOSS (NIHL)

Donald Henderson PhD

Professor

Department of Communicative Disorders and Sciences

Center for Hearing and Deafness

State University of New York at Buffalo USA

Email: donaldhe@buffalo.edu

Chiemi Tanaka MA CCC-A

PhD Candidate

Department of Communicative Disorders and Sciences

Center for Hearing and Deafness

State University of New York at Buffalo USA

Email: ctanaka@buffalo.edu

Noise-induced hearing loss (NIHL) continues to be the most common form of hearing loss in working age populations. Hearing conservation programmes can change the incidence rate of NIHL,¹ but there are occupations (e.g., construction, music) and activities (e.g., motorcycles, hunting) where personal hearing protection devices are not used as extensively or effectively. There is a growing body of research that is leading to the development of drugs to prevent NIHL and these drugs may eventually be used as a secondary approach to prevent NIHL.

Free Radical Formation and Antioxidant Treatment

The development of oto-protective drugs can be traced to recent insights on how noise damages the cochlea and causes hair cell loss. The first discovery was that high levels of noise increase free radical activity in the cochlea, especially at points of vulnerability, i.e., the outer hair cells (OHCs) and nerve fibres underneath the inner hair cells.² Normally, the cochlea is very energy consumptive

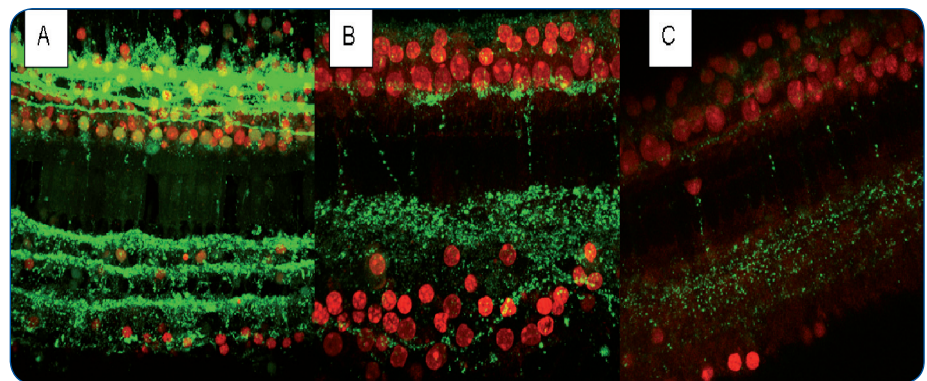


Fig 1: Organs of Corti stained with propidium iodide (red) showing nucleus and dichlorofluorescein (green) detecting a product of lipid peroxidation. A: 30 minutes post noise. B: 2 days post noise. C: 4 days post noise. The lipid peroxidation is intense for at least 2 days post noise and appears to contribute to the loss of OHCs.

and has a large population of mitochondria, especially in the OHC. The mitochondria generate superoxide O_2^- at the rate of 1 per 1000 conversions of ADP to ATP. With high level noise, the energy demands are increased in the cochlea and superoxide generation is also increased. Given that noise interferes with blood flow to the cochlea, the superoxide rate is even further increased with ischaemia/re-perfusion. Interestingly, the superoxide accumulation in the cochlea is short-lived (within hours), however, the

increased free radical state continues due to the sustaining lipid peroxidation. The lipid peroxidation is persistent, at least for several days, and its presence coincides with the continued death of hair cells after noise exposure (Figure 1).³

The realisation that oxidative stress is a key factor in the pathology caused by noise exposure has led to the development of antioxidant drugs that prevent NIHL.

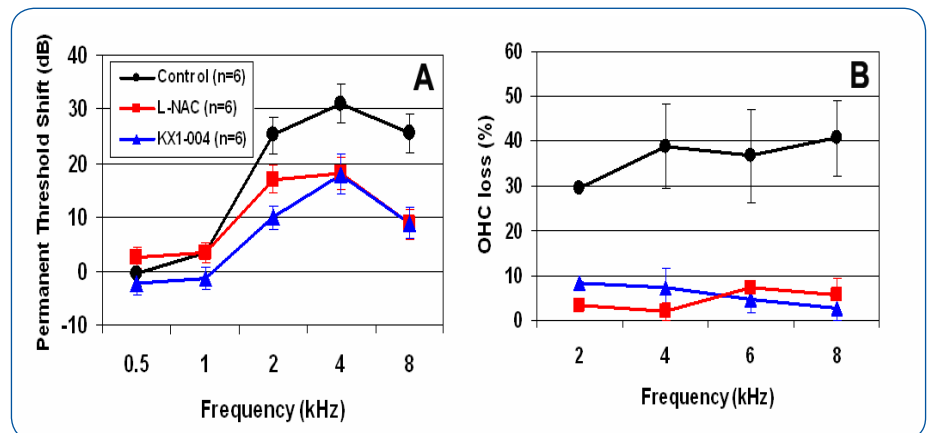


Fig. 2: A: Permanent threshold shift protection from 6 hour/day for 6 days 4 kHz octave band continuous noise afforded by systemically-administered L-NAC (red), KX1-004 (blue). The saline control group is shown in black. B: OHC protection afforded by L-NAC or KX1-004 after the same noise.

Pharmacological Prevention of NIHL

For example, three antioxidant drugs or combinations are in varying phases of clinical development:

- **N-acetyl-L-cysteine** (L-NAC, Figure 2): a pro-glutathione drug used for liver detoxification
- **AuraQuell™**: a combination of vitamins and magnesium
- **Ebselen**: another pro-glutathione drug. Each of three drugs, when given before a traumatic noise exposure, reduces the cochlear damage and hearing loss in laboratory animals. The clinical otoprotection of these drugs is very promising.

Pharmacological Prevention of Hair Cell Death

The second discovery about the effects of traumatic noise exposure is the realisation that damaging levels of noise induce sensory cell death by apoptosis.* Experiments that studied the pathology of the cochlea within minutes and hours after traumatic exposure often showed a small lesion of the OHC. However, as time progressed, the number of dead or dying cells increased. Interestingly, the OHC continued to die for several days and the mode of cell death was primarily apoptosis.⁴ Figure 3 shows typical pathology after high level noise exposures where the OHCs are separated from the supporting Deiters' cell. Cell separation from the extracellular matrix can be a trigger for apoptosis which leads

* **Apoptosis** – the process of programmed cell death that may occur in multi-cellular organisms.

to a second class of protective drugs. One of these drugs is a pharmaceutical agent which inhibits the Src gene, one of a family of nine oncogenes. Src was discovered approximately 25 years ago as viral Src (v-Src), the transforming gene in the Rous Sarcoma Virus. Src activity is elevated in many cancers and associated with the disassembly of cell to cell junction. When the non-ATP competitive Src inhibitor, KX1-004, is given 30 minutes before a traumatic noise exposure, the noise induced free radical generation is greatly attenuated and the drug provides 10 to 15 dB of hearing protection at much lower doses of the typical antioxidants (Figure 2).⁵

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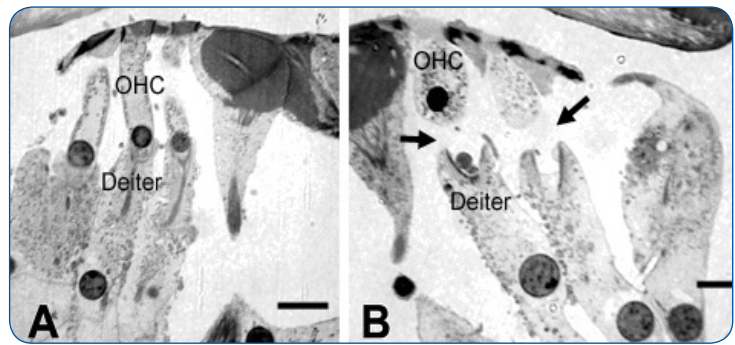


Fig. 3: Cross section of the OHC region of the organ of Corti of a chinchilla. A: Normal spatial arrangement between the OHC and Deiters' cup. B: 30 min after impulse noise exposure (75 pairs of simulated M-16 gunfire at 155-dB pSPL). The dark arrows denote points of detachment of the OHCs from their supporting Deiters' cups. Notice that the nuclei of OHC at the corresponding position show there are initial signs of apoptosis. Bar in A: 25 μ m. Bar in B: 10 μ m.

GLOSSARY (HENDERSON AND TANAKA)

ADP: Adenosine diphosphate. ADP is converted into ATP for energy production.

Antioxidant: Any substance that delays, prevents, or removes oxidative damage to a target molecule.

Apoptosis: Cell suicide. Programmed cell death through initiation of cell-destroying enzymes.

ATP: Adenosine triphosphate. The primary energy source used by cells.

Free radicals: Molecules with unpaired electrons. They are unstable and damage DNA, proteins, and lipids.

Incidence rate: Number of new cases per population in a given time period.

Lipid peroxidation: Oxidative degradation of lipids in which free radicals take electrons from cell membrane, leading to cell damage.

Mitochondria: Intracellular organelle that is responsible for the synthesis of most of the energy utilized by the cell in the form of ATP. Cellular power plants.

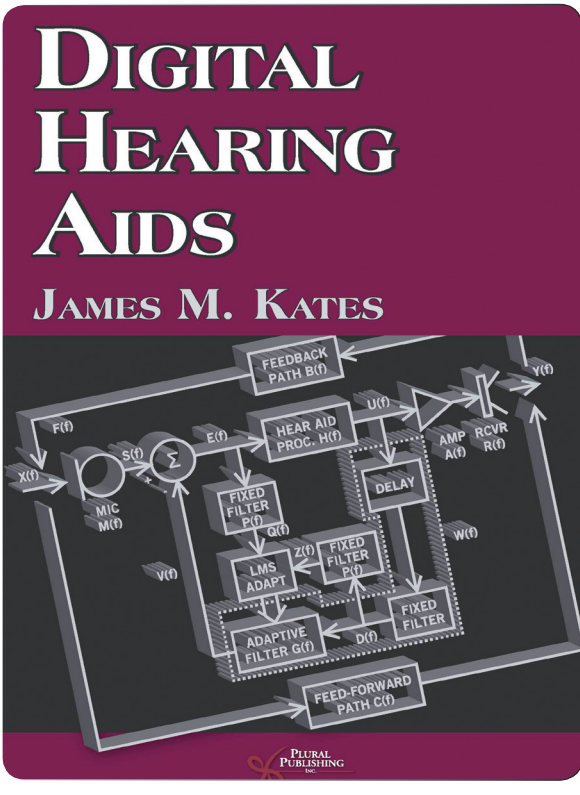
Oncogene: Mutated or highly-expressed gene which helps to turn a normal cell into a cancer cell.

Oto-protective drug: Pharmaceutical agent which is used to protect hearing.

Pro-glutathione drug: Pharmaceutical agent which helps to generate glutathione.

Superoxide: One of the oxygen-derived free radicals. Natural by-product of mitochondrial respiration which is the metabolic process to obtain energy by reacting oxygen with glucose to give water, carbon dioxide, and ATP.

BOOK REVIEW: DIGITAL HEARING AIDS



DIGITAL HEARING AIDS <i>Kates, James M.</i>	
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 Plural Publishing Inc.
 5521 Ruffin Road
 San Diego
 CA 92123
 USA
 Email:
 information@pluralpublishing.com

SYNOPSIS: This valuable resource on digital signal processing (DSP) principles and approaches is designed to inform and guide anyone interested in hearing sciences. The text focuses on the complexities of signal processing algorithms used in modern digital hearing aids and therein presumes the reader has a basic understanding of hearing aid fitting algorithms and their mathematical concepts and representations. Common features found in modern hearing aids such as feedback cancellation, wind protection screens, dynamic range compression, multiple and single microphones are described with clarity in the text and additionally illustrated with mathematical representations.

The textbook contains 13 chapters that range from the basics of analog to digital Hearing Aid Technologies, in Chapter 1 through the specific algorithms required to balance Bilateral Signal Processing in the final Chapter 13. In between these chapters, the reader is confronted with the myriad of insights and challenges to the hearing aid user including “the Cocktail Party” and other effects that compromise desired signal to noise ratios. Chapter 2 introduces Signal Processing Basics; Chapters 3 – 7 deal with the DSP hardware and algorithms: 3) the Electro-acoustic System; 4) Directional Microphones; 5) Adaptive and Multi-microphone Arrays; 6) Wind Noise; and 7) Feedback Cancellation. The remaining chapters cover signal processing related to physiological and perception dynamics: 8) Single Microphone Noise Suppression; 9) Spectral Subtraction; 10) Spectral Modifications; 11) Sound Modifications (to improve speech intelligibility); and 12) Sound Classification to help determine parameters for algorithms in challenging listening environments.

REVIEW: *Digital Hearing Aids* appears to be the first text with the sole focus on digital hearing aids. According to the author, it is designed for multiple audiences including graduate students, hearing aid dispensers, audiologist and engineers. While dry in its presentation, the text is easily understood and complete with specifics useful to those who desire to stay current with digital hearing aids technology. Within the first chapters, Kates provides a brief overview of hearing aids and DSP through a series of mathematical representations with accompanying qualitative descriptions and critical analyses. A digital hearing aid is defined more by its algorithms than by its hardware. The energy requirements of DSP are now far less than analog processors of the past. It is noteworthy in the first few pages, that the BTE digital hearing aid has a far wider fitting range and nearly 3 times the battery capacity using zinc air 675 (640 mAh) compared to the next larger size 13 that provides only 280 mAh. The author describes the under-performance of directional microphones and eludes improved alternatives through adaptive and multi-microphone arrays once power and cosmetic issues are adequately addressed. Similar treatment is given the problems of turbulent airflow. Wind noise is reduced somewhat in CICs and ITE devices and by (frequency limiting) wind screens. Feedback cancellation, one of the author’s areas of research, can be reduced by mathematically modeling the feedback path that is then subtracted from the microphone signal. The alternative of gain reduction that reduces needed amplification. The Dynamic-Range Compression Chapter creates the false impression that compression algorithms and electronic programming are unique to the DSP. The debate over fast (syllabic) versus slow compression time began in the late 1980s, and the last generations of analog hearing aids included compression technology and electronic programming.

The text offers a good analysis of the problems associated with developing noise suppression algorithms and the need to find ways to compensate for imperfect frequency signal processing. Kates, in Chapter 10, suggests Spectral Subtraction can filter the speech masked in noise. “One can think of spectral subtraction as starting with a distribution of noisy speech magnitude samples measured over some time interval, and then adaptively adjusting the gain in each frequency band so that the distribution of the processed magnitude samples more closely represents that of clean speech” (p. 291). Easier said than done? Hearing loss appears to be more than a sum of separate processing issues. An answer, according to Kates, may be to model the normal and the impaired ears. “The hearing aid filtering is then adaptively adjusted so that the output from the model of the impaired ear, even the process

Book Review

input matches as closely as possible the output from the model of the normal ear" (p.350). The last chapters on Sound Classification and Binaural Hearing seek classification algorithms to discriminate speech from non-speech sounds and binaural transmission links for interaural synchronization.

CRITIQUE: *Digital Hearing Aids* author James Kates is a well-known and respected hearing aid engineer currently developing algorithms including the DFS feedback cancellation algorithm with GN

Resound. He is also an academic at the University of Colorado and formerly at City University of New York. The text-book's intended wide audience includes accomplished engineers as well as graduate students. The former will be more familiar with the mathematical concepts and representations than graduate students and practicing audiologists who might find challenges with the numerous mathematical representations.

Throughout the text, the author's solid descriptions of hardware and algorithms

and his critical analysis of the challenges yet facing engineers in the industry left this reader, at the end, wanting to suggest changing the title to "*The Potential of Digital Sound Processing to Improve Hearing Aids*".

Ron Brouillette PhD

CBM Advisory Group on the Prevention of Hearing Impairments Handicap International, Advisor on Disabilities



ABSTRACTS

AUDIOLOGIC AND VESTIBULAR FINDINGS IN A SAMPLE OF HUMAN IMMUNODEFICIENCY VIRUS TYPE-1-INFECTED MEXICAN CHILDREN UNDER HIGHLY ACTIVE ANTIRETROVIRAL THERAPY

Palacios GC, Montalvo MS, Fraire MI, Leon E, Alvarez MT, Solorzano F

Departamento de Infectología Hospital de Pediatría Centro Médico Nacional Siglo XXI Instituto Mexicano del Seguro Social (IMSS) Cuauhtemoc 330 Colonia Doctores Delegación Cuauhtemoc Mexico City 06720, Mexico

Email: palsaugc@gmail.com

Objective: There is little information about audiologic and vestibular disorders in pediatric patients infected with the Human Immunodeficiency Virus type-1 (HIV-1). The aim of this study was to evaluate audiologic and vestibular disorders in a sample of HIV-1-infected children receiving Highly Active Antiretroviral Therapy.

Methods: Patients underwent pure tone audiometry, speech discrimination test-

ing, auditory brainstem responses, electronystagmography, and rotatory testing. HIV-1 viral load and absolute CD4+ cell counts were registered.

Results: Twenty-three patients were included, aged 4.5 years (median, range 5 months to 16 years). Pure tone audiometry was carried out in 12 children over 4 years of age: 4 (33%) showed hearing loss, 2 were conductive. Auditory brainstem responses were measured in all 23 patients, suggesting conductive hearing loss in 6 and sensorineural hearing loss in 2. Most patients with conductive hearing loss had the antecedent of acute or chronic suppurative otitis media but with dry ears at the time of evaluation ($p=0.003$). Abnormal prolongations of interwave intervals in auditory brainstem responses were observed in 3 children (13%, 4 ears), an abnormal morphology in different components of auditory brainstem responses in 4 (17.4%, 7 ears), and abnormal amplitude patterns in 11 patients (48%, 17 ears). Vestibular tests were abnormal in all six patients tested,

with asymmetries in caloric and rotatory tests. Although differences were not significant, in general, audiologic abnormalities were more frequent in patients with more prolonged HIV-1 infections, higher viral loads, or lower absolute CD4+ cell counts.

Conclusions: Conductive hearing loss associated with previous otitis media events, abnormalities in auditory brainstem responses suggesting disorders at different levels of the auditory pathways, and unilateral vestibular hyporeflexia were frequent findings in our sample of HIV-1-infected children under Highly Active Antiretroviral Therapy. These findings suggest that HIV-1-infected children should be submitted to audiologic and vestibular evaluation as early as possible in order to reduce their impact on the psychosocial development of these patients.

Int J Pediatr Otorhinolaryngol. 2008; 72(11): 1671-1681.



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OTOLOGICAL FINDINGS AMONG NIGERIAN CHILDREN WITH SICKLE CELL ANAEMIA

Alabi S, Ernest K, Eletta P,
Owolabi A, Afolabi A,
Suleiman O

Department of Otorhinolaryngology
College of Health Sciences
University of Ilorin
Ilorin
Nigeria

alabibs@yahoo.com

Background/aim: Various degrees of hearing loss have been associated with sickle cell anaemia, especially of the sensorineural type (SNHL). However, there is little information on hearing pattern among sickle cell children in Nigeria. This study is to determine the prevalence of sensorineural hearing loss (SNHL) among children with sickle cell anaemia (SCA).

Patients and methods: Eighty (80) stable children aged 4-15 with Hbss attending the pediatric sickle cell clinic and also 60 control patients with HbAA, matched for age, sex at the pediatric general medical clinic of the University of Ilorin teaching hospital, Ilorin, Nigeria, all had prospective study of their pure tone audiological assessment (PTA) and tympanometric evaluations done over a year period.

Results: Their age range was 4-15 years with a mean of 9.4 for the Hbss and 9.7 for the control group. The male/female ratio was 1.3:1 and 1.5:1 for SCA and control subjects respectively. 25 subjects (50 ears) had abnormal audiograms among the SCA subjects and OME was the cause in 22 subjects and only three (3) had mild SNHL which was bilateral. However, in the control group 15 had abnormal audiograms and all were due to OME and none had SNHL. OME was bilateral in 19 subjects with SCA, two on the left and only one on the right. In the

control group, 11 of the OME was bilateral and only four were on the left side. The prevalence of SNHL was 3.8% and OME was 27.5%.

Conclusion: We have found a prevalence rate for SNHL of 3.8% for 80 subjects with HbSS, and all cases have been a mild bilateral high frequency SNHL. Our findings suggested that SNHL is uncommon in early childhood, specifically during the years of language acquisition and early schooling. This could mean an age dependant prevalence rate of SNHL among SCA patients. However, no difference in the incidence of OME among both groups which can lead to educational difficulties from the resultant speech and language defects.

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HEARING IMPAIRMENT AND SOCIOECONOMIC FACTORS: A POPULATION-BASED SURVEY OF AN URBAN LOCALITY IN SOUTHERN BRAZIL

Béria JU, Raymann BC, Gigante LP, Figueiredo AC, Jotz G, Roithman R, Selaimen da Costa S, Garcez V, Scherer C, Smith A

Graduate School of Public Health
Medical School
Lutheran University of Brazil
Canoas
Rio Grande do Sul
Brazil

Objective: To provide the first population-based data on deafness and hearing impairment in Brazil.

Methods: In 2003, a cross-sectional household survey was conducted of 2,427 persons 4 years old and over. The study population was composed of 1,040 systematically chosen households in 40 randomly selected census tracts (dwelling clusters) in the city of Canoas,

which is in the state of Rio Grande do Sul, in southern Brazil. Hearing function was evaluated in all subjects by both pure-tone audiometry and physical examination, using the World Health Organization Ear and Hearing Disorders Survey Protocol and definitions of hearing levels. The socioeconomic data that were gathered included the amount of schooling of all individuals tested and the income of the head of the household. Results: It was found that 26.1% of the population studied showed some level of hearing impairment, and 6.8% (95% confidence interval (CI) = 5.5%-8.1%) were classified in the disabling hearing impairment group. The prevalence of moderate hearing loss was 5.4% (95% CI = 4.4%-6.4%); for severe hearing loss, 1.2% (95% CI = 0.7%-1.7%); and for profound hearing loss, 0.2% (95% CI = 0.03%-0.33%). The groups at higher risk for hearing loss were men (odds ratio

(OR) = 1.54; 95% CI = 1.06-2.23); participants 60 years of age and over (OR = 12.55; 95% CI = 8.38-18.79); those with fewer years of formal schooling (OR = 3.92; 95% CI = 2.14-7.16); and those with lower income (OR = 1.56; 95% CI = 1.06-2.27).

Conclusions: These results support advocacy by health policy planners and care providers for the prevention of deafness and hearing impairment. The findings could help build awareness in the community, in universities, and in government agencies of the health care needs that hearing problems create.

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- To promote ear and hearing health in developing countries

Objectives

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- To provide a forum for the exchange of ideas, experience and information in order to encourage improvements in the delivery of ear and hearing health care and rehabilitation.

Correspondence/Enquiries to:

Professor Andrew W Smith

International Centre for Eye Health

*London School of Hygiene and Tropical Medicine
Keppel Street, London WC1E 7HT, United Kingdom*

Email: Andrew.Smith@lshtm.ac.uk

Dr D D Murray McGavin

World Care Consultancies

*West Hurler House, Glasgow Road
Glasgow G53 7TH Scotland, UK*

Email: murray.mcgavin@yahoo.co.uk

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