Are you having problems hearing? If so, those around you already know it. Hearing loss is no laughing matter, so don't be a punchline.

– Leslie Nielsen

# Ears & Hearing Loss

Photo: courtesy Mark Paton

## Care & Relief

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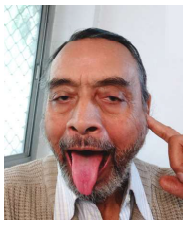
## Precis of practical routines for proper hearing

**Hearing loss is a terrible thing because it cannot be repaired.**
**– Pete Townshend**

However, the general belief, articulated by Mr. Townshend, may not be entirely correct. Based on actual experience, a few rather simple routines can tone up hearing and may be able to repair hearing loss:

1. Minimize exposure to noise pollution: Much hearing loss is due to damage from noise. Minimize noise pollution. Loudness and duration of time are major factors in hearing loss. [see within the booklet for info.]

2. Modified *Bhramari* (a yoga technique):Insert index fingers in the ears, breathe in and press-release, press-reliease fingers in the ears continuously while making mmmmmm sound during exhalation. Breathe normally twice and do it again. In all practise 5 times in one session; 3 sessions a day.



3. Drop-Jaw routine: Eject tongue to the full. Do it 15 times. Place finger to the side of the ear to feel the movement & exercise of ear components.

4. Air-Pressure in Mouth: Puff up the mouth like a balloon. Do it 15 times. Provides movement & exercise of ear parts from pressure within the mouth cavity.

5. Ear lubrication: Dip little fingers in organic yellow mustard oil and apply in the ear canal with a circulatory movement at least once a day.

# Ears & Hearing Loss

> Perhaps it is not the decibels that are causing the deafness, or that appear to make people ill or mental cases. Perhaps it is the fact that the unremitting clangor, this uncoordinated racket of our technological age, is so discordant and grating.
>
> But Nature, it now has been discovered, is building up a permanent defence against the nerve-dissolving, killing hubbub by gradually causing the ears of the citydweller to go deaf. It appears that the only adaptation the human ear knows to the constant pounding and thrumming it receives is by eliminating *all* sound stimuli. It is, without doubt, better to be stone-deaf than raving mad.
>
> - Robert Rienow & Leona T. Rienow, *Moment in the Sun*, 1967

Vision and hearing are perhaps the two most important sensory functions in our commerce with the external world. Communicating with people, listening to birds, enjoying music, etc. are some of the most enjoyable activities in our life. Our ancestors depended on the acuity of hearing for their very survival in the jungle, and we too may thank this capacity of hearing to literally survive on the roads of our urban jungle. It is also a fact of life that whereas people are invariably sympathetic and tolerant to the disability of blindness, they get easily annoyed when faced with deafness if they have to repeat words twice or thrice or to have to converse in a louder voice. It is possible that this irritation is a consequence of higher energy outlay required to generate louder sounds. Another probable reason could be the hidden nature of the hearing debility, for unlike blindness external signs of deafness are not apparent.

Like other sensory organs, the human sense of hearing is also under siege today. “As of 2013 hearing loss affects about 1.1 billion people to some degree (Lancet. 386 (9995): 743–800). It causes disability in about 466 million people (5% of the global population), and moderate to severe disability in 124 million people” [Wikipedia].

Regrettably, with man’s capacity to generate deafening noise, not infrequently as fashion or fad, noise induced hearing loss (NIHL) around the globe is proliferating alarmingly. Otherwise, the human ear is a remarkably sturdy organ. Hardly any fatigue is associated with its function in the normal milieu.

### How can proper hearing be maintained through life?

To clearly understand as to how to care for the sense of hearing, let us consider the nature of sound and the anatomy of the organ of hearing.

## Sound

**Waves** transport energy through a medium. Sound waves are typically longitudinal waves causing particles of the medium (e.g. air, water, metal) to oscillate. The particles regain their stationary stance after energy transfer to adjacent particles in each wave cycle. Waves can transport a great deal of energy: as an example, consider the tremendous erosion caused by ocean waves to rocks and cliffs over time.

Typical characteristics of sound waves are described by the following functions:

Speed: In normal conditions, sound waves travel through air at a speed of some 340 meters (1,120 feet) a

second.

Length: Each wave propagates in a certain direction. A full wave-cycle consists of a crest and a trough, and each cycle is denoted as a Hertz (Hz). The length of sound waves perceptible to human ear varies a great deal, from approximately 1.7 centimeters to 17 meters at normal pressure and temperature in air.

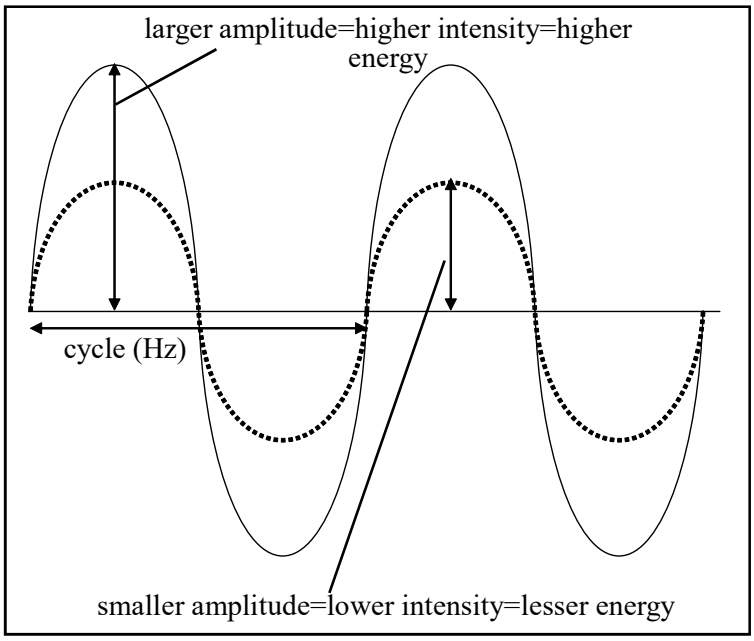
Frequency: The number of full cycles of a wave per second denotes its frequency expressed in Hz. Frequency determines the pitch of sound, and is inversely related to length of the wave. Low pitch sounds are longer waves, lower frequency. High pitch sounds consist of shorter length and higher frequency. Although human ear can detect sounds as low as 20 Hz and as high as 20,000 Hz at the extremes, the normal hearing range is 1,000 - 4,000 Hz. Dogs and bats can hear ultrasonic sounds - beyond human range, of 50,000 Hz or more. Sounds produced by volcanoes and earthquakes are less than 20 Hz and are referred to as infrasonic or subsonic. Elephants and whales communicate over long distances by using infrasonic sounds.

The following equation gives the relationship between speed, frequency and wavelength:

Speed (meters/second) = Length (meters) x Frequency (in Hz)

For normal sound in air with speed of 340 meters per second, unique parameters for length or frequency can be calculated using the above relationship. For example, the length of waves at 1000 Hz is:

340 = Length x 1000 or 340/1000 = 0.34 meter = 34 cms




And the frequency of a 17 millimeter wave is:
340=.0017 x Frequency or 340/0.0017=20000 Hz

Amplitude: If a sitar string is pulled a tiny bit, it will vibrate air particles merely in the middle region since little energy was applied and transmitted through the oscillations. The amplitude is small. If the string is pulled hard, the wire vibrates from top to bottom causing oscillation of air particles to a larger extent and much more energy is carried by the wave.

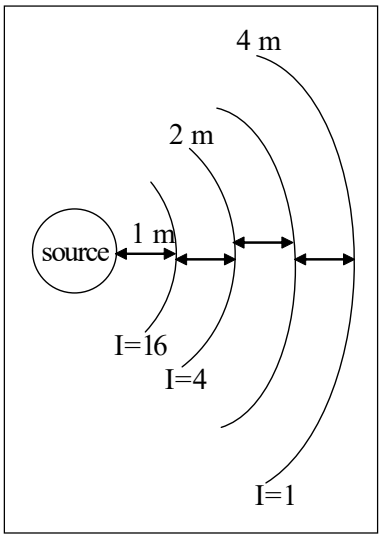
The amount of vibrational energy propagated by the wave is called **Intensity** and it is directly related to the amplitude. Intensity comparisons are therefore energy comparisons. The intensity of sounds produced by natural phenomena and living beings can vary tremendously.

For example, the human ear is capable of perceiving sounds whose energy variation is 100 trillion-fold (1 followed by 14 zeros). Scientists therefore have devised a simpler way to compare the Intensity level of sound, known as a decibel scale.

Decibel: For ease of reference and comparison purposes, the intensity is stated as **sound pressure level** (**SPL**), the amount of pressure exerted by air particle vibrations generated by sound waves. Values of sound pressure levels are compared to barely perceptible sound detected by human ear at a frequency of 1,000 Hz which is arbitrarily assigned a reference value of 0 decibel on the decibel scale. It is a logarithmic scale and each 10 fold increase in SPL is denoted by adding 10 to the decibel number. Thus sound of whispering leaves is10x10x10=1,000 times more intense than barely perceptible sound (0 dB) and is denoted by 10+10+10=30 decibels. Heavy city traffic is 10x10x10x10x10x10x10x10x10 =1,000,000,000, that is a billion times more intense than barely perceptible sound, and thus has a billion times greater vibrational energy depicted by 90 on the decibel scale.

Loudness: The loudness depends on intensity, frequency and duration of the sound and is a subjective perception of an individual. For comparison purpose, however, a general rule of thumb is: loudness doubles with each increase of 10 decibels.

Intensity & Distance Relationship: As the sound travels away from the source, the intensity gradually diminishes because the vibrations keep getting dispersed over a wider area. A mathematical link, known as *inverse*




*square relationship*, is observed between the intensity and distance: as the distance doubles, the intensity diminishes 4-fold. For example, if the intensity at one meter from the source is taken to be 16, then at 2 meters (doubling of distance), the intensity is reduced to 4 (16 divided by 2x2); at 4 meters, the intensity diminishes to 1 (doubling of distance from 2 to 4 meters leads to a division of intensity by 4). This property is of immense importance when considering the impact of normally audible sounds in the 1000 - 10000 Hz range on human health.

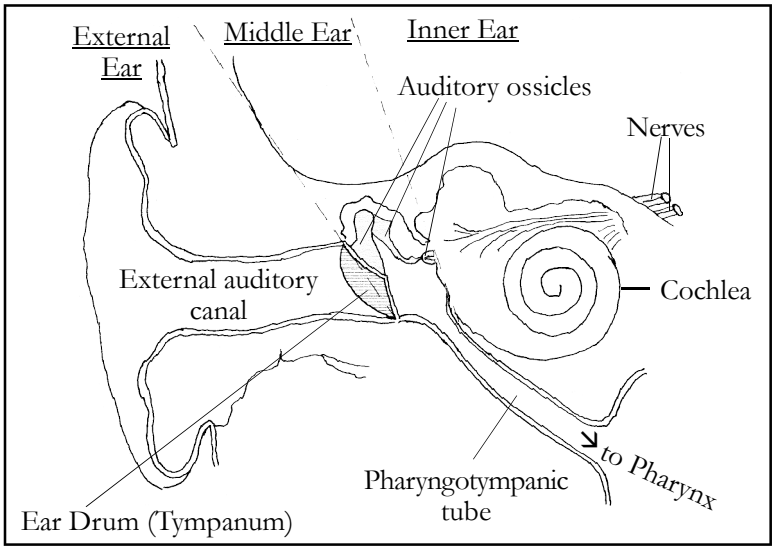
It should be noted that low frequency and ultrasound frequency sounds are not so dissipated by distance. Short-waves (high frequency, 3 - 30 MHz) travel great distances in the air but require special instrument (radio receiver) to reconvert them to audible sound. Low frequency sounds (approximately 20 - 400 Hz) do not necessarily lose their intensity according to inverse square relationship, and infra-sounds (1 - 20 Hz) can actually travel hundreds or thousands of kilometers by hugging the ground or in water. Besides, the low frequency sounds backed by higher amplitude (higher energy) can rattle and vibrate even buildings, such as jet planes do when flying at low altitudes.

## Anatomy of the Ear

Human ear is divided in to three distinct parts:

1. The visible external ear catches the sound and directs it through the external auditory canal towards the eardrum (**tympanum**).

2. The middle ear houses three tiny ear bones or auditory ossicles which carry the sound vibrations from the tympanum to the inner ear enhancing them some 15-30 times during the transmission. This is primarily due to the significantly smaller size of **oval window** (through which the signals are transmitted from the middle to the




inner ear) compared to the tympanum on to which the first impact of the sound waves occurs. This smaller size helps concentrate the vibrational energy.

3. The inner ear contains a 3.5 centimeter long coil, shaped like a snail shell structure, known as **cochlea**. Cochlea houses some 15,000 hair cells, each of which

has 100 fine hair like shafts, **stereocilia**, on the surface. The hair cells convert mechanical vibrations in to electrical impulses which are then transduced via the 30,000 – 40,000 nerve fibres of the **auditory nerve** to the brain where the actual hearing takes place.

### What causes loss of hearing?

Malfunction of the hearing process or deafness is divided into two main categories:

1. Conductive deafness is caused by a blockage in the external or the middle ear. In the external ear temporary blockage due to water or ear wax could impede the flow of sound. A more serious inhibition in the transmittal of sound vibrations may occur due to perforation of the eardrum or loss in the mobility and flexibility of the ear bones (auditory ossicles) of the middle ear.

2. Nerve deafness, is caused by a problem in the transmittal of sound vibrations in the inner ear because of nerve malfunction; or more typically it is due to 'sensorineural' hearing loss in consequence of damage to the delicate hair cells as a result of aging, diseases & infections from bacteria & viruses, ototoxic medications, or heredity. But, by far, the most common culprit of **damage to hair cells is noise**, alone or in combination with other agents.

### What is noise? How does it differ from sound?

To define noise absolutely is a difficult proposition as the perception of sound can be so subjective. Generally however, any background sound which forces you to raise your voice in normal conversation can be classified as noise. Based on extensive animal and clinical research

across the globe, experts have compiled extensive data on sound pressure levels and their impact on the organ

| Level of sound from | SPL (dB) | Loud-ness* | Hearing loss after |
|---|---|---|---|
| Barely audible sound to human ear | 0 | - | None |
| Whispered voice | 30 | - | None |
| Refrigerator humming | 40 | - | None |
| Sound level in average home | 40 - 50 | - | None |
| Normal conversation | 60 | 1 | None |
| Car on highway with closed windows | 70 | 2 | None |
| Home and car audio | 84 - 108 | 6-14 | 8 hr-2 min |
| Power tools | 85 - 113 | 6-28 | 8 hr-90sec |
| Music in fitness classes | 89 - 96 | 8-12 | 3 hr-45 min |
| Heavy city traffic | 90 | 8 | 2.5 hr |
| Music in dance bars | 90 - 110 | 8-32 | 2.5 hr-90 sec |
| Motorcycle | 95 | 12 | 45 min |
| Wood shop, Snowmobile | 100 | 16 | 15 min |
| MP3 players, iPods (Full volume) | 105 | 24 | 5 min |
| Chain saw, Rock concert | 110 | 32 | 90 sec |
| Ambulance siren | 120 | 64 | 30 sec |
| Thunderstorm | 120 | 64 | 30 sec |
| Behind Boeing 707 ready to take off | 120 | 64 | 30 sec |
| Boom equipment: car, home, functions | 120 -140 | 64-256 | 30 sec-instantly |
| Gunshot | 140 | 256 | instantly |
| Firecracker, gunshot | 150 | 512 | instantly |
| Space Shuttle launch | 180 | 4096 | immediate |

Intensity of sound as, Sound Pressure Level=SPL in dB=decibel, * Loudness range with normal conversation assigned as base 1, hr=hour, min=minute, sec=second
'Loudness' and 'Hearing loss after' times are approximate, but do provide an estimate and comparison of the hazards from noise pollution
Information accessed in December 2009, and tabulated from the following sources:
"*How Loud is Loud*"; http://www.nidcd.nih.gov/health/hearing/ruler.asp
Health Canada; http://www.hc-sc.gc.ca/hl-vs/iyh-vsv/index-eng.php
"*A Warning that Falls on Deaf Ears*"shttp://www.timesonline.co.uk/tol/life_and_style/health/expert_advice/article716510.ece
"*Boom Car Noise*", http://www.lowertheboom.org/trice/BoomCarNoise.pdf

of hearing (see table).

### How to discern which noises are injurious to hearing?

Three factors pertaining to loss of hearing are important,

and they follow from the discussion about sound above.

Firstly, the **intensity**, i.e. the sound pressure level exerted on the ear..

Secondly, the **amount of time (duration)** the sound is allowed to impact hearing.

Thirdly, **nearness to the source** of sound, since most audible sounds rapidly decrease with distance.

The above three factors have been described simply as, “too loud, too long, too close.” A new term 'Noise Induced Hearing Loss (NIHL)' has also been coined to differentiate hearing impairment from less common causes. The table above summarizes **sound pressure level** of sounds in decibels, with perception of loudness in normal conversation as reference, and the amount of time beyond which permanent hearing loss occurs due to irreparable damage to hair cells.

It should be noted that the SPL between 70 to 80 dB is somewhat of a gray area. Some studies have elicited the conclusion that prolonged exposure to SPL above 70 dB can result in hearing loss which may or may not be reversible.

### What to do to minimize NIHL?

Government regulations generally address and formulate mandatory guidelines for protecting the employees from work place noise. Environmental noise from air, road, and railways traffic is a much more difficult proposition to tackle. Citizen groups in conscious communities strive to petition government bodies for relief with ambiguous outcomes. Sometimes they do work. In some western countries, city governments have banned flights

from and in to airports during hours of repose. But in India, we are still far from that kind of awareness and action.

One of the major causes of NIHL, however, over which individually or collectively we do have partial or full control is gadgetry used in leisure activities. Such noise sources include, sport events – regular or competitive, motor racing, powerful motor bikes, snowmobiles, water skiing, off-road vehicles – lawn mowers, vacuum cleaners, shooting, firecrackers, toys, religious activities which until a few decades ago were conducted without loud broadcasts perhaps with equal fervor, weddings and celebrations, concerts and personal music systems.

This last is the one source of potential noise which is on a dramatic rise globally since the introduction of walkman in the 1960s. A respected USA website describes this threat to hearing in the following words: "In 2001, it was estimated that 12.5% of American children between the ages of 6 to 19 years had impaired hearing in one or both ears. As many as 80% of elementary school children use personal music players, many for extended periods of time and at potentially dangerous volume settings. There is little doubt that the use of consumer products, which produce increasingly high levels of noise and which are used with headsets or earphones, is growing and may well be responsible for the impaired hearing that is being seen with growing frequency in younger people. [http://www.medscape.com/viewarticle/554566_7 [retr Dec 15, 10].

Health Canada experts after reviewing scientific literature and conducting tests arrived at the same conclu-

sion: "All combinations of **headphones/earphones and CD players** could generate **potentially harmful sound levels**".

It should also be noted that impulse sounds 140 decibels and above - such as generated by gunshot, toys, and firecrackers – do cause permanent damage to hair cells instantly.

"At UK cinemas, sound levels of 110 dB have been recorded. A report by the TUC and RNID in 2004, *Noise Overload*, suggested that music played in nightclubs is so loud as to be comparable, in some cases, to standing 2 ft away from an aeroplane as it takes off (110 dB). At concerts the volume can reach 125 dB and even aerobics classes can exceed 90 dB. The pain threshold for sound is 140 dB", reports *The Times*, London, in its January 2006 article *A warning that falls on deaf ears.* SPL of 110 dB can cause hearing loss during the screening of the movie itself.

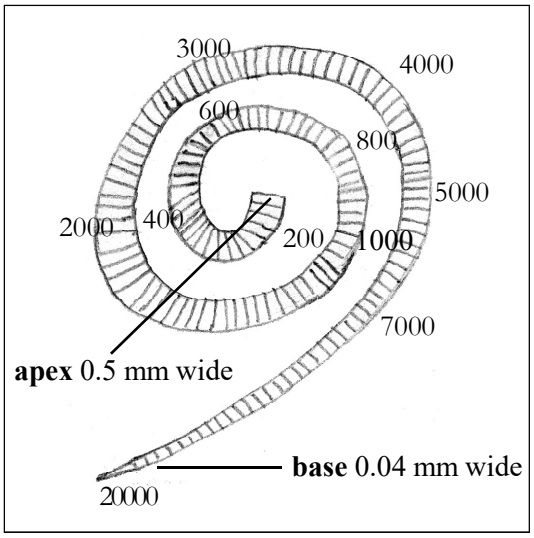
A few years ago in a movie theatre in New Delhi, I too found the sound level truly offensive to the ears and the brain. Nobody else seemed to be at all bothered. My young relative commented, "Oh, this is the normal level in all theatres and I think it is quite alright." This incident seemed to confirm the recurrent reports that young people today may be hearing impaired by 20-30 dB. To avoid any hearing impairment, it may be prudent to heed Health Canada's advice "to **keep the sound enjoyable … but [at] safe levels**" and to "**limit the time**" of listening to personal music systems.

WHO (World Health Organization) cautions that children may be more susceptible to NIHL and, there-

fore, further recommends: "To avoid hearing impairment, impulse noise exposures should never exceed a peak sound pressure of 140 dB peak in adults, and 120 dB in children." Please also note that some ototoxic medicines, chemicals and vibrations may induce hearing impairment at such low sound pressure levels as 70 dB.

### Does the pitch (frequency) figure in NIHL?

Yes, it does. As noted earlier, hair cells and stereocilia are located on the cochlea. The apex of the cochlea adjoins the middle ear through the oval window and the base is at the centre of the spiral. Diverse frequency sounds are picked up by hair cells in specific regions of cochlea. Low frequency sounds stimulate hair cells near the apex and higher frequency near the base (see the drawing). Consequently, whatever the frequency of damaging sounds is, NIHL occurs in the same frequency region on the cochlea.




**Warning**: There is mounting evidence that the comparatively new fad and fascination of primarily the youth with **low frequency and infrasound combined**

**with high levels of SPL is an extremely dangerous trend.** The music entertainment industry brings out equipment with ever more powerful vibrations. World Health Organization (WHO) specifies, "For indoor environments, reverberation time is also an important factor. If the noise includes a large proportion of low frequency components, still lower guideline values [of SPL in dB] should be applied." As mentioned earlier, low frequency sounds do not obey the inverse square relationship to distance, and therefore even outdoor events such as weddings and functions using **boom equipment** are a **threat** to all and sundry as a health hazard in more ways than just hearing impairment. [http://www.lowertheboom.org/trice/BoomCarNoise.pdf ; Accessed Dec 18, 2009]. Because of the tremendously powerful vibrations which can cause even the buildings to shake, the effect of low frequency and infrasounds on human organs other than of hearing can be significantly deleterious.

### What? Are there other hazards to human health than hearing loss from noise?

Long term noise is a comparatively recent phenomenon, and is in a large measure the product of technology. Until recently, it was believed that noise can create debility in the function of hearing and the research more or less centered on that aspect alone. Over the past decades, with more experimentation and diagnosis, it has become apparent that NIHL is but one of the problems associated with noise. WHO has identified additional health hazards directly from noise or accentuated by noise:

1. **Interference with communication**: Obviously

background noise interferes in normal conversations as well as classroom and any other kind of learning sessions where an audible perception is essential for understanding. In a noisy setting, important informative signals – phone, fire alarm, buzzers and door bells, horn on heavy traffic roads – are less audible and may result in untoward consequences.

2. **Sleep disturbance effects**: Sound sleep is necessary for health. The body rejuvenates itself during sleep after the physical, emotional & mental activities carried out during the waking hours. Behavioral research has shown that lack of proper sleep can cause headache, short temper, irritability and tiredness over the short run and loss of productivity, augmentation of disease, and even depressive mental states over the long run. SPL of 30 dB or below should be maintained as far as possible for providing good sleep.

3. **Cardiovascular and psychophysiological effects**: There are indications that persistent noise levels even in the 65-70 dB levels may cause heart disease. Sporadic reports in the scientific literature also suggest other effects such as changes in hormone & mineral levels, and adverse indications in the immune and gastrointestinal systems. More research is needed to elicit unequivocal relationship between noise and adverse effects on human organs.

4. **Mental health effects**: An explicit cause and effect link of noise to mental disorders has not been established. But observations such as significantly higher number of prescriptions for tranquilizers & sleeping pills with increased incidence of psychiatric symptoms and hospi-

talizations do imply "that adverse mental health effects are associated with community noise".

5. **Performance level effects**: Although not much research has been done relating noise to work productivity, it is obvious that any activity that requires some mental concentration is likely to suffer by noise. There is evidence that noise retards reading acquisition in early childhood, and that longer exposure leads to greater damage. WHO affirms that "it is clear that day-care centres and schools should not be located near major noise sources, such as highways, airports and industrial sites."

6. **Annoyance responses**: "Annoyance is defined as a feeling of displeasure associated with any agent or condition … The term annoyance does not begin to cover the wide range of negative reactions associated with noise pollution; these include anger, disappointment, dissatisfaction, withdrawal, helplessness, depression, anxiety, distraction, agitation, or exhaustion. Lack of perceived control over the noise intensifies these effects", quotes the website Medscape citing scientific literature.

7. **Social behavior effects**: Many antisocial behavior changes instigated by noise have been documented. These include depriving people from the use of their own spaces like yards & balconies, an inclination to change residence & locality, aggressiveness, unfriendliness, verbal abuse, quarrels & fights, nonparticipation, and even drug consumption and hospitalizations.

India must be one of the noisiest countries in the world. What with events from multiple religions on a daily or festival basis, weddings & functions, political rallies & frequent election campaigns, protest marches

& strikes, perpetual horn blowing throughout the day & night on the streets & roads, stray dogs howling at all hours, radio & TV & stereo songs loudly played in houses and shops, the tremendous cacophony in Indian villages, towns and cities is beyond belief. For sick people, students, and normal citizens endeavoring to cope with the stress of life, it is sheer agony day in and day out. As it is, in India, we are less civic minded as is evident from loud conversations face to face or on mobiles in trains well past the normal hour of repose.

Though the Supreme Court in its rulings has acknowledged the grievous problem of noise, nothing much can be done unless statutes of penalty stiff enough to dampen the ardor of the perpetrators are enacted and implemented. Law enforcement in India is in any case feeble. It is likely that if noise were treated and enforced as a **health menace on par with passive smoking**, which it actually is even at a greater distance, the distressed citizens may get some welcome relief.

## Can anything be done to keep the function of hearing healthy?

Based on actual experience, not only can one prolong acuity of hearing throughout one's life but also curtail hearing loss to a lesser or larger degree by the practice of a judicious regimen based on common sense precautions and simple routines, despite the general belief articulated by Mr. Townshend in the quote below:

Hearing loss is a terrible thing because it cannot be repaired. – Pete Townshend

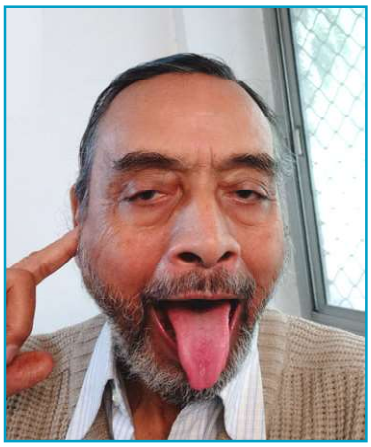
This salubrious regimen consists of the following:

1. Minimize exposure to noise pollution. Earlier in this treatise is a fairly detailed discussion about noise, its sources and impact. Although the hearing apparatus is generally quite robust, there is any number of sources of a potentially damaging nature to our hearing mechanism in today's mechanized society; and one needs to find ways to decrease the impact of harmful noise on their own person.

2. Modified *Bhramari pranayama* (a yoga technique): Plug ears with index fingers. Breathe in deeply. Slowly exhaling through the nostrils make a mmmmmmmm sound with lips pressed together, simultaneously press-release, press-release index finger in the ears, until the air from the lungs has been totally expelled. The pitch of the sound goes up and down like the sound of a buzzing bee. One can feel the lips and eardrums vibrating. Take a deep breath again and repeat. Do this 5 times. Takes about a minute. Do 3 sessions a day; better on a comparatively empty belly.

**Caution**: This routine should not be practised if there is any discharge from the ear, for that may further exacerbate the problem.

3. Drop-Jaw routine: Throw out the tongue to the full extent (see picture on next page). Do it 15 times. Place finger on side of ear to feel the movement & exer-



Drop-Jaw

Air-Pressure in Mouth

cise of ear muscles, tissues, bones and associated nerves.

4. Air-Pressure in Mouth routine: Puff up the mouth like a balloon. Do it 15 times. Provides movement & exercise of ear muscles, tissues, bones and associated nerves from pressure within the mouth cavity.

5. Ear lubrication: Dip little fingers in organic yellow mustard oil and apply in the ear canal (external ear orifice) with a circulatory movement at least once a day. Absorption of this oil helps lubricate the ear components and also softens the ear-wax for facile removal.

Benefits: The great benefit that accrues from these simple routines is the stimulation and toning up of all components of the hearing apparatus. Regular practice should lead to a delayed aging of the hearing apparatus, and also curtailment of hearing loss.

**Air travellers** who suffer from **ear-blocks and pain**, sometimes excruciating pain, due to enhanced pressure in the ear at the time of landing in an aeroplane can benefit immensely with regular practice of modified

*bhramari pranayama* (#2 above) routine.

An added benefit of Drop-jaw routine (#3 above) is the strengthening of the jaw bone & associated muscles, and also throat muscles..

## Aspiration

विश्वं पुष्टं ग्रामे अस्मिन्ननातुरम्।।

– *Yajurveda* 16:48

In this village [global village],
may all sentient beings be robust and healthy

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