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Noise-Induced Hearing Loss (NIHL) – Still A Major Occupational Health Problem

B. Holt[1] and S. A. Malik[2]

Abstract

High level of noise in the work environment (especially in the manufacturing and construction industry) is always seen as a major problem in all parts of the world. It has been studied that prolonged and repeated exposure to loud noise can affect human hearing which may lead towards permanent hearing loss. Noise induced hearing loss (NIHL) at the workplace is seen as one of the major occupational health problems and the topic has gained a lot of popularity in the recent past. Prior research confirms that NIHL is the second most common form of hearing loss after age-related hearing loss; however, it can be avoidable. This article can be seen as an information guide as it addresses the topic of NIHL by providing an extensive review to cover various factors associated with NIHL and how the problem can be avoided (prevention) as well as treated (when it occurs). We believe that the information provided in this article would certainly benefit occupational health nurses.

Keywords: Occupational Health, Noise-Induced Hearing Loss (NIHL), Loudness, Anatomy of Human Ear, Health and Safety, Risk Management, Hearing Conservation, Measuring Noise Exposure, Pre and post noise exposure.

1 Introduction

Previous research in the area of occupational health suggests that employees' physical and mental health should be the top priority of organizations as employees' good health is good for business (i.e. it increases the overall productivity which of course produces better results especially when we look at it from a financial perspective). According to the recent Labor Force Survey (2014), in the UK in 2013, 131 million working days were lost

[1]Director of Policy and Research at International Institute of Risk and Safety Management.
[2]Technical and Research Manager at International Institute of Risk and Safety Management (IIRSM).

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due to sickness absences, which means 4.4 working days per worker. This includes minor illnesses, stress, anxiety, depression, musculoskeletal problems and several other medical conditions. Figure 1 shows that the trend is going downwards while comparing with previous years; however, the problem is still significant and requires a lot more attention.

Figure 1: Number of working days lost (Source: Labor Force Survey, Office for National Statistics, 2014)

Amongst these several physical and mental health issues, over the past several years, noise induced hearing loss at workplace is seen as one of the major occupational health problems and this cannot be ignored. It has been known for many years that exposure to sudden, very loud noises, such as gun fire or explosions, could result in loss of hearing as a result of damage to the ear drum. However, the industrial revolution saw the establishment of several new activities such as the textile industry where spinning and weaving operations produces lower levels to which workers were exposed for extended periods. This exposure was still found to cause hearing loss over an extended period. In fact, this problem has become the commonest form of occupational hearing loss.

As seen in ILC-UK (2014), according to the research by Action on Hearing Loss (2011), an estimated 10 million people in the UK are affected by some degree of hearing loss and this is likely to increase over the coming decades. By 2031, a massive 14.5 million people in the UK will have hearing loss accounting for 19.8% of the total population. For people with hearing loss of at least 35 decibels (i.e. moderate hearing loss and above) numbers will increase from just over 6 million today to over 10 million by 2037. The report also mentioned that the problem is costing billions to the UK economy and to some degree, it has been neglected.

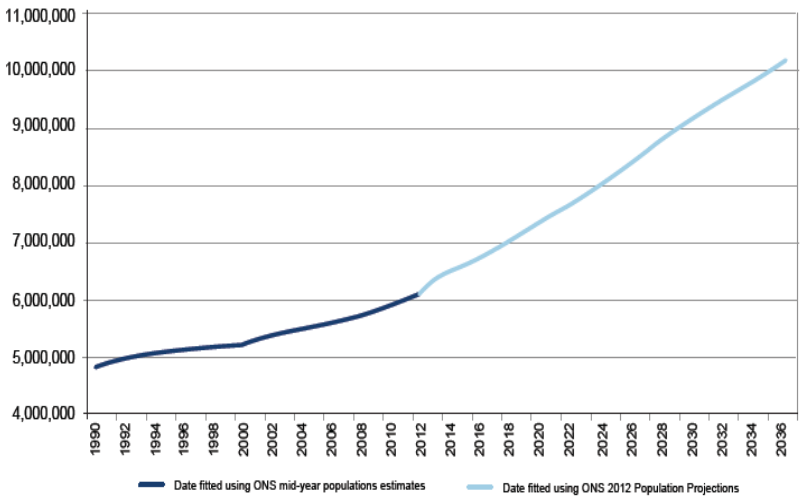

Figure 2: Estimates the number of people with hearing loss of at least 35db across the UK 1990 - 2037 (Source: ILC-UK, 2014)

The UK Health and Safety Executive (HSE, 2015) claims that throughout all industry in the UK, industrial hearing loss remains the occupational disease with the highest number of civil claims accounting for about 75% of all occupational disease claims. According to the latest results published on HSE (2015), in the UK, there were 120 new claims in 2013 about NIHL compared to 125 and 150 in 2012 and 2011 respectively. Similarly, an estimate 18,000 people currently have NIHL that was caused or made worse by work related activities; these numbers are based on the data from the latest three LFS surveys (2010/11, 2011/12, 2013/14).

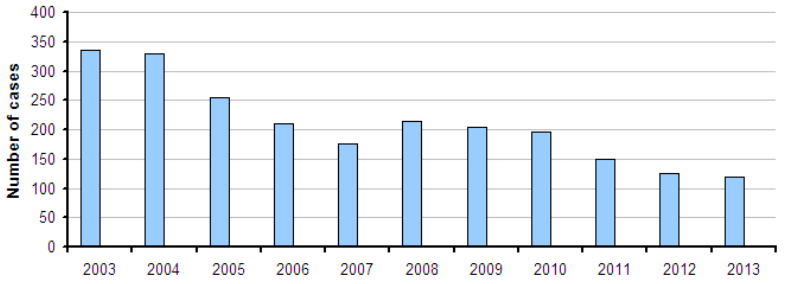

Figure 3: The number of cases of noise-induced hearing loss (NIHL) in the UK (Source: HSE, 2015)

An important factor regarding noise induced hearing loss (NIHL) is that it is irreversible. Once a worker's hearing has deteriorated as a result of extended exposure to workplace noise, the loss cannot be repaired.

This paper mainly highlights the key factors associated with noise-induced hearing loss which we believe requires a lot more attention. The paper can also be seen as an information guide as it covers detailed information about how the problem occurs and

why we need to consider taking early precautions. The paper aims at educating both workers and line managers about several health-related risks which may occur if personal protective equipment (PPE) are not considered while working in a noisy environment. But first, let us start our discussion in the next section explaining how sound travels and reaches to us and how certain level of noise causes damage to human ears which ultimately leads towards hearing loss.

2 Propagation of Sound

As seen in Health and Safety International (2014), unfortunately for many years in industries (such as in textile industry) due to the loud noises from the machinery and other equipment, workers, without realizing and focusing on the seriousness of this problem, always developed ways of communicating with each other such as through lip reading or even talk louder with each other etc. To understand how various noises affect human hearing, we first need to understand the nature of sound transmission and the structure of human ear. Sound is transmitted through the air in the form of longitudinal or compression waves. These consist of alternating areas of higher and lower pressure, as shown in following figure 4.

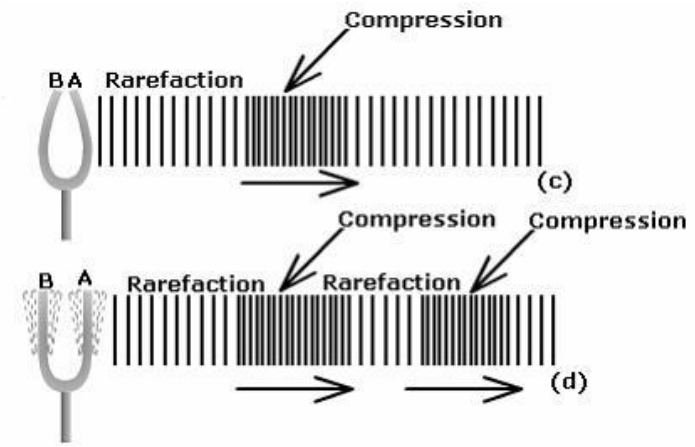

Figure 4: Propagation of sound waves in air from a tuning fork (Source: Tutor Vista, 2015)

The properties can also be shown in the form of a sine wave which illustrates the key variables, frequency, wavelength and amplitude.

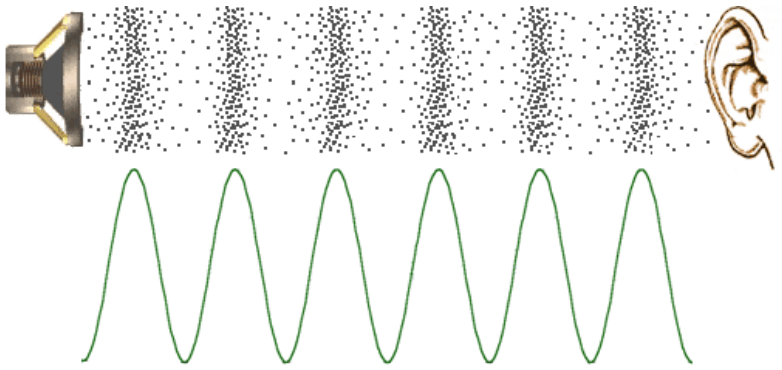

Figure 5: Speaker sound wave (Source: Tutor Vista, 2015)

The frequency, which is related to the wavelength, is the number of vibrations per second and it is important because the ear responds differently at certain frequencies. The frequency/wavelength is the characteristic that allows us to recognize the pitch of a sound; whether it is high or low. The range of frequencies to which the human ear responds, are normally in the range 20Hz to 20kHz. Within this range, hearing responds differently at different frequencies and as we get older, the range particularly at higher frequencies is reduced. The response to different frequencies becomes important when we are selecting control measures, as we shall see later.
The amplitude is a measure of how loud the sound is and is shown by the depth of the sine wave. This is the factor on which legislative standards are based.

3 How does Noise lead to Hearing Loss?

To understand the mechanism behind noise induced hearing loss, we need to consider the structure of the ear and the way in which sound pressure waves are transformed into 'signals' that are transmitted to the brain. Similarly, the ear can be divided into three main regions, *the outer*, *middle* and *inner* region as shown in figure 6. The outer ear (the part that we can all see) is the part which collects the sound pressure waves and channels them into the middle and inner ear. The middle ear comprises the ear drum and a sequence of bone linkages which transform the air movements into physical motion which is in turn transmits to the inner ear. The middle ear itself can be the cause of problems such a Meniere's disease that causes symptoms such as tinnitus and loss of balance. It can also lead to hearing loss but the loss from this cause is normally temporary.

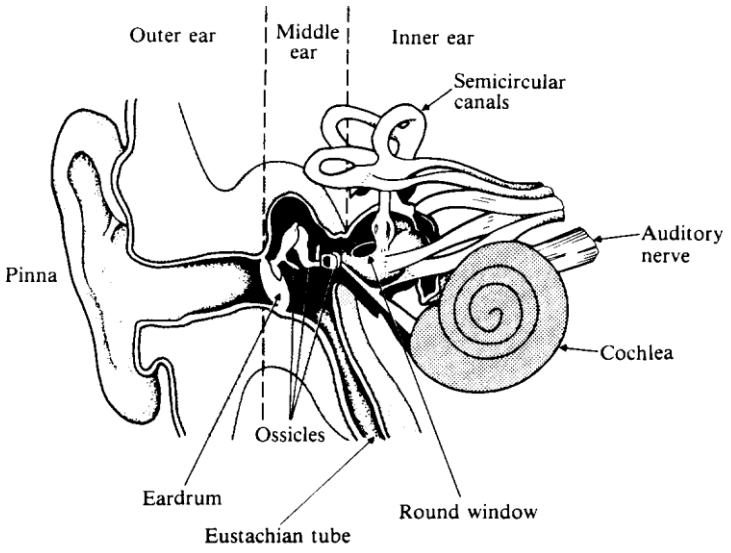

Figure 6: Schematic Diagram of Human Ear (Source: CityU, 2015)

In terms of extended exposure to noise, the key component is the "cochlea" which is the spiral 'snail like' structure located within the inner ear (right side of the diagram above). This is filled with fluid in which there are nerve cells called "cilea". These transform the mechanical motion into minute electrical signals, which are then transmitted to the brain via the auditory nerve.

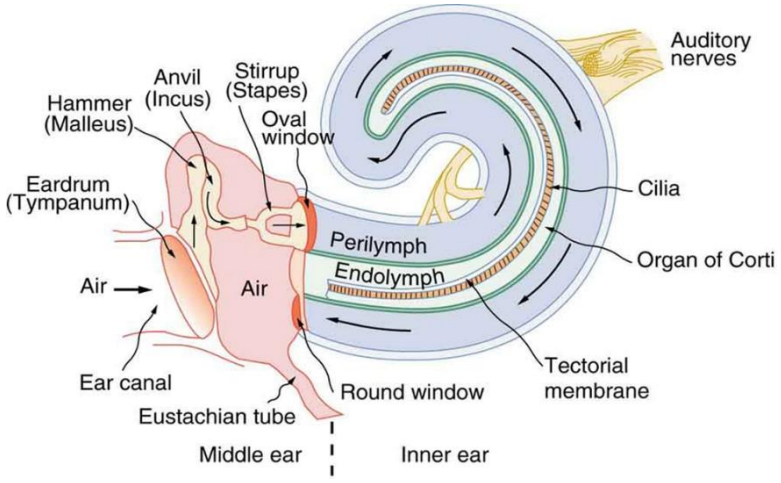

Figure 7: The inner ear (cochlea) (Source: CNX, 2015)

In the event of exposure to high noise levels over an extended period, these cells are damaged irreversibly leading to noise induced hearing loss (Health and Safety International, 2014).

4 At What Level does Damage Occur?

If we are to understand the levels at which noise induced hearing loss can occur, first we need to understand how sound pressure levels are measured. These are measured in a unit called decibels, (dB). In considering the effect on hearing, we normally use a scale known as the 'A' weighted scale, or dB(A). This responds most closely to the frequency response of the human ear, which detects sound within the middle of the hearing range, 1 – 8 kHz, most sensitively.

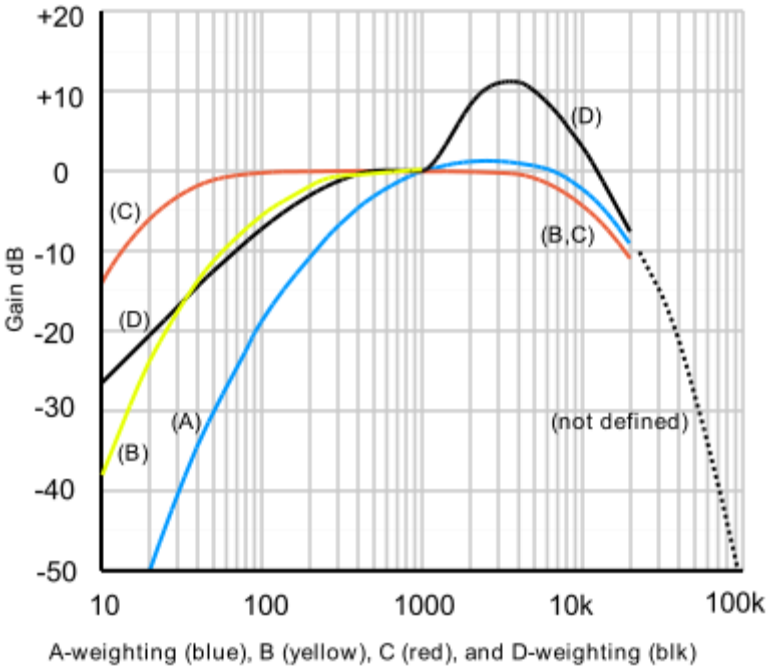

Figure 8: A graphical representation of the A-weighting over the audible frequency range as well as additional frequency weightings (Source: Noise Monitoring Services, 2015)

The A-weighting is mandated in IEC 61672 to be fitted to all sound level meters with precision meters being also fitted with C-weighting mainly for testing purposes. The B & D weighting scales have largely ceased to be used although the D-weighting is now only used for measuring noise levels of military aircraft engines (Health and Safety International, 2014).

Now let's cover few examples to explain different noise levels which may cause hearing loss. As explained in the introduction section, it had long been recognised that exposure to sudden loud noises can lead towards hearing loss. For instance, the sound pressure level of a gunshot is likely to be around 140-190dB(A) (depending on the type of weapon) which can cause hearing loss as a result of rupture of the eardrum. Similarly, when listening to a personal music system with standard earphones at a maximum volume, the sound generated can reach a level of over 100dB(A) which is loud enough to begin causing permanent damage after just 15 minutes per day (Dangerous Decibels, 2015). However, workers in occupations, where they were encountering sustained levels much lower than this, also suffer from noise induced hearing loss. Figure 9 shows a noise

thermometer with some other examples to cover different noise levels.

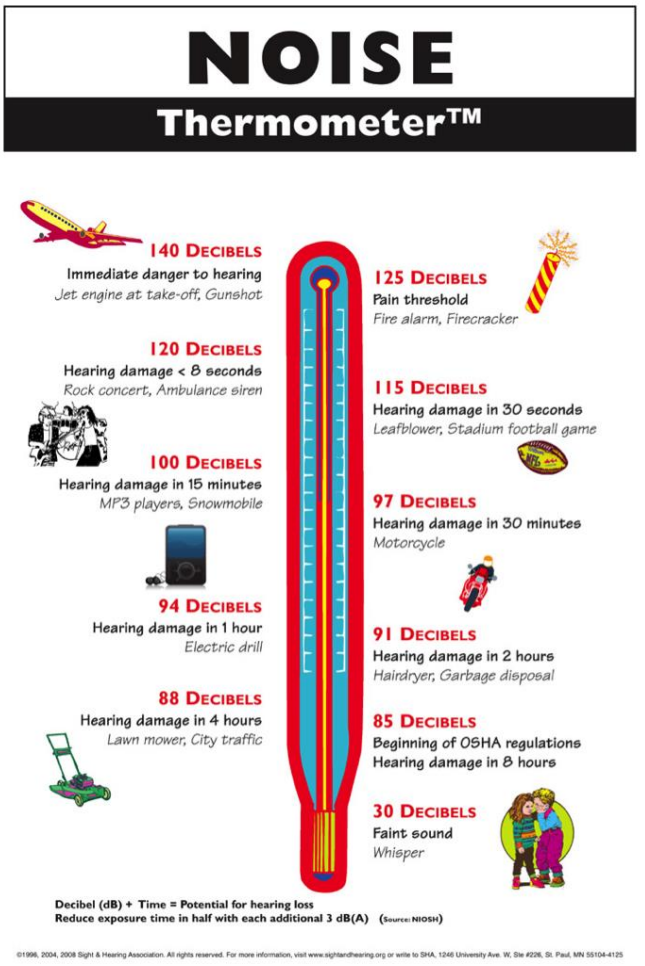

Figure 9: Noise Thermometer with Different Noise Levels
(Source: Dangerous Decibels, 2015)

5 Measuring Exposure

To understand whether there is a need to carry out a programme of noise measurement, a rule of thumb (which is often used) is that it should be necessary for someone to raise their voice to be heard by another person at arm's length, the ambient noise level is likely to be close to the statutory limit, in which case more detailed measurement should be made. So how do we measure the actual sound level? There is a range of measuring devices that can be used, each of which is designed for a specific purpose. IEC 61672-1 specifies three types of "sound measuring instrument", i.e. the *conventional* meter, the *integrating-averaging* meter and the *integrating* sound level meter.

For the purpose of assessing the risk of hearing damage, the conventional meter is of limited value, simply giving a snapshot in time, while the integrating meters will give

estimate a time averaged value known as L_{at} or L_{eq}, which is a continuous (Root Mean Square) exposure level which would be equivalent to the variations on level over the reference period. In some cases, such as where the sound arises from impacts it is also necessary to measure peak sound pressure level. This could, for example, be in a metal stamping workshop. This would be measure using the 'C' weighting scale. In the EU, the maximum value for peak sound pressure level is 140dB(C), which corresponds to a peak pressure of 200Pa.

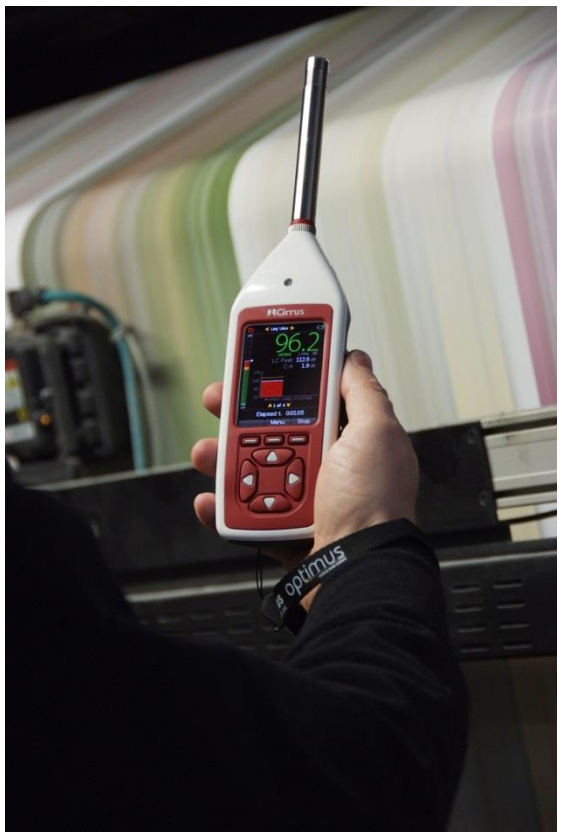

Figure 9: A typical sound level meter (Source: Cirrus Research Plc, 2015)

Sound level meters are classified under IEC 61672-1 into two types. These can carry out the same functions but Class 1 meters have a wider frequency range and tighter tolerance for error but are, as a result, much more expensive. Normally, these are only used for research or enforcement work and a Class 2 meter is normally sufficient under national standards for workplace noise assessment. Whichever class of meter is to be used, it is essential that it is used with the equivalent type of calibrator. This is a device that couples with the meter and emits a sound at defined frequency and amplitude. This allows the calibration of the meter to be checked before & after use.

As the aim is to measure the exposure of an employee to excessive noise levels, in some cases it may be necessary to use a personal sound exposure meter (dosemeter). This is a device that is worn by an employee who may be working in different areas where he/she is exposed to different sound levels during the course of the day. Ideally the microphone of the device should be worn close to the ear. Personal sound level meters are now subject

to their own international standard, IEC 61252:1993 (Health and Safety International, 2014).

6 Controlling Noise Exposure

In all relevant standards including EU Directive 2003/10/EC (European Agency for Safety and Health at Work, 2015a), national standards in member states and the US OSHA standard 29 CFR 1910.95 (United States Department of Labour, 2015), the requirement is that exposure above the designated action levels must be controlled in accordance with good risk management practice. In the EU Directive, this is defined as in accordance with the general principles of prevention, set out in Directive 89/391/EEC (European Agency for Safety and Health at Work, 2015b). This means that there is a hierarchy of controls to be followed. These include:

- Eliminating the source of excessive noise levels;
- Replacing equipment with that which creates less noise;
- Using technical measures (e.g. enclosing the equipment or operators, or using noise absorbing mountings, etc.);
- Changes in the working methods (e.g. reducing duration of exposure or moving operators away from the noise source);
- Personal protective equipment (PPE) in the form of ear plugs and ear muffs can be used in certain circumstances, namely:
  - As a temporary measure until more effective measures can be put in place;
  - Where noise reduction measures on their own are unable to reduce the exposure to an acceptable level.

Where hearing protectors are provided as a control measure, this imposes certain duties on the employer such as to provide information about the risk of NIHL, instruction about the control measures that have been put in place and training in their correct use. Employers, on the other hand, also have the duty to ensure that PPE is being regularly and correctly used. This can be part of a routine workplace inspection programme carried out by managers and supervisors. Where noise reduction measures including PPE are not being used correctly, managers and supervisors should ensure that the employee received the correct information are training and identify whether there is any practical reason, such as comfort, that needs addressing (Health and Safety International, 2014).
To control noise levels and its exposure within the work environment, Holt (1997) in his book on '*principles of health and safety at work*' proposed different methods; some of these are as follows:

- *Engineering Controls* – while purchasing equipment, organisations need to consider the ones with low vibration and noise characteristics, and achieving designed solutions to noise problems including using quieter processes (e.g. presses instead of hammers), designed dampers, making mountings and couplings flexible, and keeping sudden direction and velocity changes in pipework and ducts to a minimum.
- *Orientation and Location* – moving the noise source of the heavy machinery away from the work area or even turning the machine around to avoid excess noise.

- *Enclosure* – noise can be reduced by surrounding the machine (or other noise source) with sound-absorbing material; the effect can be limited unless total enclosure is achieved.
- *Use of Silencers* – these can be useful to suppress noise generated when air, gas or stream flow in pipes or are exhausted to atmosphere.
- *Damping* – this can be achieved by fitting proprietary damping pads, stiffening ribs or by using double skin construction techniques.
- *Screens* – these are effective in reducing direct noise transmission.
- *Absorption Treatment* – this can be done in a form of wall applications or ceiling panels; these must be designed for acoustic purposes to have significant effect (Holt, 1997).

7 Prevention and Treatment (Pre and Post Noise Exposure)- What needs to be done?

7.1 Prevention (Pre Noise Exposure) – Hearing Protection with some Useful Recommendations

To avoid hearing loss, wearing a proper hearing protection equipment is always seen as an obvious and popular choice. When selecting appropriate hearing protection equipment, a number of factors must be taken into account; some of these are as follows:

- *It is important to ensure that devices are a good fit* – This can be an issue with the use of ear muffs by employees who wear spectacles or require safety spectacles/goggles.
- *Employee preference* – Hearing protection is only of use if employees actually wear it. It is good practice to offer a choice that includes different styles as some employees may prefer in-ear devices whereas others are happier with over-ear protection.
- *Correct usage* – If in-ear protection is provided, for example in the form of foam plastic inserts, it is essential that wearers are shown the correct way to insert the plugs. It may seem obvious, but they are designed to be compressed and then when inserted into the ear canal they expand to provide a good seal. If you see a piece of coloured foam plastic hanging from an employee's ear, he/she will be getting negligible protection.
- *Disposable or reusable* – It is also important for employees to understand that some of these inserts are designed to be temporary and should not be reused as they can become contaminated and cause ear infections. With over-ear protection, these should be regularly cleaned and stored in a place where they are not likely to get contaminated. I'm sure we have all seen earmuffs lying on a work-bench collecting dust.
- *Compatibility with other protection* – In situations where safety helmets must be worn, the use of normal earmuffs can compromise the impact protection. Protectors can be provided that attach to the outside of the safety helmet but the degree of attenuation may be less than with a standard version.
- *Measure distribution levels* – When selecting hearing protection, it may be necessary to measure the distribution of levels within different octave bands as each device will provide a different attenuation profile across the audible frequency range. This data is provided with the devices and should be used in selection process.

- *Providing relevant information* – To provide information about the risk of noise induced hearing loss, instruction about the controls measure which have been put in place and providing training about their correct use.
- *Ensuring that the information provided is properly used* – To ensure that the equipment are being correctly used; this can be part of a routine workplace inspection programme carried out by managers and supervisors. Where noise reduction measures including PPE are not being used correctly managers/supervisors should ensure that the employee has had the correct information and training and try to identify whether there is any practical reason, such as comfort, which should be addressed.

7.2 Treatment (Post Noise Exposure)

If the problem occurs, several things need to be considered for reducing further damage. Some of these are as follows:

- *Avoidance* **–** It is quite obvious and mostly agreed by the occupational health experts that the best way to prevent from any future noise related injuries is to avoid noise exposure. Also, it is recommended to avoid things that may/can contribute to ear damage (e.g. try to avoid taking any ototoxic drugs such as aspirin, and avoid whenever possible exposing yourself to the situations where your ear may be damaged (such as listening to loud music, scuba diving etc.).
- *Moving noisy machinery/plant away from workers* – It is important to move any noisy machinery/plant to the areas where there are no workers (e.g. arranging a dedicated room for any noisy equipment).
- *Hearing aids* – these are small, battery-powered electronic devices that enhance sounds to make them louder and clearer, helping someone with hearing loss to hear better and feel less isolated in everyday situations. These are in several shapes and styles and can be worn on the ear or in the ear. However, they all work in a similar way using the same five elements.
  - *Microphone* – picks up sound and converts it into digital signals;
  - *Amplifier* – modulates the digital signals, makes sounds louder or quieter;
  - *Receiver* – converts the amplified signal into sounds and feeds them into the ear;
  - *Microchip* – enables the tuning and personalisation of your hearing aid to your individual needs;
  - *Battery* – the hearing aid gets power from tiny batteries (Age UK, 2015).

8 Discussion and Conclusion

The article has provided an extensive review of the issues relating to noise induced hearing loss that is still seen as a major issue for organisations. The aim of this article has been to show that the elements of a risk management approach can be applied to this problem and to draw attention on some of the issues that need to be addressed by implementing a hearing conservation programme.

In the past, provision of hearing protection has often been the knee jerk response but, while acknowledging this has a role to play, there are other elements that must be considered first and it is essential that the programme is seen as an on-going part of

occupational health management.

Occupational health nurses are often the first point of contact which an employee has relating to exposure to health risks. This puts them in a unique position to identify an employee who may be showing early symptoms of noise induced hearing loss. If it is known that a worker is involved in an activity generating hazardous noise levels, the nurse can be alert to signs of hearing damage before it becomes obvious to the worker. At this stage, the hearing loss is irreversible so the earlier a problem can be identified the better it is for all parties. For the employee, action can be taken to ensure that it does not deteriorate further, reducing their quality of life, whilst for the employer the problem can be dealt with before they are exposed to an expensive claim.

Clearly it is to the benefit of all that this risk is identified at a stage when action can still be taken and here is the value that an occupational health nursing programme can add.

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