Noise-Induced Hearing Loss: Engineering Control at Industry and Clinical Audiology Approach at Hospital Level

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Abstract. In today’s increasingly complex industrial design and size, noise is one of the serious hazards to hearing. Loss of hearing as a result of long term exposure to high level noise at industrial sector is become one most potential harmful for workers. In line with this concern, engineering control design has been adapted at industrial level as prevention approach and as a part of occupational safety and health culture at workplace. While hearing impairment of workers due to high level of noise exposure require proper hearing rehabilitation strategy at clinical level. This paper discusses briefly some of the engineering control adapted at industrial scale as a prevention strategy of hearing impairment and audiological assessment and management for the workers in risk for hearing impairment at clinical level.

1. Introduction

Noise is any unwanted or unpleasant sound that has potential to cause injury and affect the health and quality of life of a person. Excessive exposure to noise, especially at work place, will cause damage to hearing structure, that’s lead to noise induced hearing loss (NIHL). Exposure to noise depends on many factors, such as duration of exposure, the magnitude of sound pressure, spectral content and the character of the noise either continuous, varying, intermittent, or impulsive.

Hearing loss is associated to accoupatation and nonaccooputaion causes. Occupational hearing loss is one of the most common work-related illness in the world. NIHL associated with occupational can be caused by a one-time exposure to an intense “impulse” sound, such as an explosion in industries, or by continuous exposure to high intensity sounds over an extended period of time, such as noise generated in a manufacturing process.

Most of the industrial sectors associated with this occupational disease are forestry, fishing, mining, transportation, quarry, manufacturing and construction. Exposure to excessive noise in these industres becoming the the most common preventable cause of hearing loss in workers of every country in the world [1] where estimated 16% of the disabling hearing loss in adults in the world is associated to occupational noise[2].
The Department of Occupational Safety & Health, Malaysia in 2014 reported 2648 cases of work diseases, of which 78.1% were attributed to NIHL [3]. While in Great Britain, it is estimated that 20,000 workers suffer from noise-induced hearing loss caused by their working environment based on data from the Labour Force Survey (three year average period 2013/14-2015/16), equating to a rate of 62 cases per 100,000 workers [4]. In Germany, 4−5 million people which 12−15% of the workforce are due to exposure to high magnitude of noise which defined as hazardous by WHO [5].

A study conducted by Crandell et al. (2004) estimate slightly higher, 11 million Americans exhibiting some degree of permanent noise-induced hearing loss and 40 million in at-risk associated to their working environment [6]. However, in comparing to developed countries, the effects of the exposure to occupational noise are reported higher in the developing regions [7].

Therefore, it is important to reduce the risk of hearing loss at the place or in situ by adopting the engineering noise control measure. Audiological assessment and management practice at hospital level aims to reduce the hearing impairment due to workplace conditions. Hence, this paper discuss briefly the engineering control strategies practice in the industry to reduce noise level to prevent mass damage to hearing, and also some of the audiological assessment and management for the workers at risk for NIHL at hospital level.

2. Engineering controls

Increasing size and types of industries increased the demand for strategies in order to reduce the negatives impact to environment and people. Similar to other types of hazard, noise induced hearing loss is preventable through a hierarchy of controls. The use of engineering controls is prioritized over administrative controls and personal protective equipment (PPE). Ear plug and other hearing protection devices are form of PPE generally used in industries to deal with noise pollution issue. However, the problem with this approach is PPE only protect the wearer but not the entire workplace that exposed the problem. On the other hand, Engineering control involve modifying, replacing workplace in order to reduce or eliminate any potential hazard in the wider scope.

Assessing the applicability of engineering controls is a sophisticated process. There are several steps need to follow in evaluation the applicability of engineeringcontro. First, identify and define the noise problem which include measuring the magnitude of noise levels and level of exposure on employee and the need for noise reduction. Next, identification of individual noise sources and an assessment of their affects to the overall noise levels. Following these identification and assessment, selection and development of appropriate engineering control. However the selection criteria will be influenced, to some extent, by the cost of purchasing, operating, servicing, and maintaining the control [8]

This type of control measurement involved the protection in first phase or known as design phase and at control the hazard at its potential source which cover more large space, personnel and more effective. Prevention through design is found to be effective in reducing the number of injury and illness cases reported in the workplace and minimizing cost associated with these cases [5].

With regards to noise hazard in industries, Engineering controls require physical changes to the workplace such as redesigning equipment at the noise source or along the transmission path to reduce the exposure of worker to high magnitude of noise. For example, re-design the continuous mining machine which is used in coal mining industries to reduce excessive noise that might cause the hearing impairment of mine operators. The flight bars and the conveyor belt tail rotor of the machine were coated with special synthetic crystalline compound that able to reduce noise and
improve the life span of the equipment [9]. Liu (2003) reported an innovative silencer known as duct resonator array was installed at the diffuser in large centrifugal compressor that effectively reduced the sound level of the machine. There are several companies that prefer to buy quiet equipment rather than modifying their equipment to reduce noise pollution [10]. For example, in one of the successful noise control collaborations between Mining companies and NIOSH, the mining companies are committed to ‘buy quiet’ equipment [11].

Another form of engineering control in design phase is by modifying the workplace or facility-related noise at the source to reduce risk related to hearing impairment. This may involve placing an acoustical shield between the noise source and employee and enclose or isolate the noise source. A complete enclosure that equipped with a closed top improved noise reduction as compare to partial enclosure. However, the design still needs some opening area for personal and equipment flow [11]. In a Practical Guide manual for preventing occupational hearing loss published by NIOSH, often a noise-related machine may be completely enclosed which allow the operator who operating the machine remain outside of the enclosure [8]. The noise reduction design of workplace manifests advantages not only to the operator but also to all the adjacent areas.

In addition to modification and design of equipments and facilities, modification of process design also can be adopted under engineering control program to reduce the negative effect of noise in industries. Most of industries which have the risk and exposure to both noise and chemicals include painting, printing, boat building, construction, metal products, chemicals, petroleum, leather products, furniture making, agriculture, and mining. [12-13].

Studies showed clinical testing indicates that combine exposure to noise and solvents such as toluene, ethylbenzene, trichloroethylene induces synergistic adverse effects on hearing. [12,9]. The adverse effects of these chemicals and other ototoxicity chemicals can be seen as damage to cochlear hair cells, central nervous system, or both [14]. Thus, substitution of chemical that would not produce negative synergistic effect with noise in a process production is preferable in a workplace.

Apart from the design phase, proper maintenance procedure could reduce and minimise the noise from the source (ie.equipment). Reduction of noise resulting from friction between metal parts could be reduced by use lubrication or use of soft elastic interspacing on the parts. Other example is reduction of mechanical shock between parts by using conveyor belts instead of chutes to avoid noisy falls, covering metal tables, metal wheels, etc. with a material, such as rubber [15].

As explain above, engineering control has been adopted using different approaches to limit the risk of hearing loss at industries. On the other hand, at hospital level, initiating appropriate health surveillance program and continuous periodic audiological evaluation are regarded as the key to reduce the damage of hearing loss [16] whereby Metidieri et al., (2013) [16] found these audiological management can lead to rehabilitation through individual actions and group therapies.

3. Assessment of hearing: Pure tone Audiometry

Audiometric evaluation is crucial to the success of the hearing loss prevention program, since it is the only way to determine whether occupational hearing loss is being prevented. Management must allocate sufficient time and resources to the audiometric program to allow accurate testing; otherwise, the resulting audiograms will be useless.[8]

According to Factories and Machinery (Noise Exposure) Regulations, (1989), “Hearing status of each individual working in noisy environment should be tested in yearly basis” [17]. The test must
be preceded by a period of quiet of at least fourteen hours to eliminate the potential of temporary threshold shift (TTS) in the test results [16]. Pure tone audiometry is a standard test used to test hearing, where the softest intensity level of sound perceived by individuals at certain frequencies will be plotted and displayed in an audiogram.

The pattern of an audiogram begins with an elevation in hearing threshold around the 3-6 kHz region of the audible spectrum leading to a ‘notch’ in the audiogram, may suggest presence of NIHL. In classic presentation, a notched sensorineural hearing loss is noted at 4000 Hz that should be relatively symmetric, as displayed in Figure 1. The degree of noise induced hearing loss that occurs is dependent on the level of noise, how long someone is exposed to it, and to some extent on individual susceptibility [14].

![Figure 1: Audiogram in NIHL](image)

Patient presence with NIHL will commonly complaint of tinnitus which is the phantom perception of sound in the absence of other physical sound [19]. Studies carried out by a group researchers on relationship between tinnitus and hearing loss found that 85 to 90% of the individuals with tinnitus present some level of hearing loss[20]. The perception of sound can be in the form of buzzing, ringing, or hissing, and can be continuous or intermittent. Tinnitus could be severe enough causing stress, hearing and sleep disturbance, and impact individual daily life.

4. Clinical approach; Diagnosis, Counseling & Recommendation

As part of audiological assessment approach, detailed history on patient current and past workplace, duration of work, also their past medical history is documented. Patient present with the pattern of NIHL, will be notified and a proper counseling conveyed. Counseling given on the aspects of effects of hearing loss, that result in major communication difficulties due to loss of sensitivity and clarity of high pitched sounds and inability to discriminate speech sounds particularly in the presence of background noise [21]. These difficulties will result in substantial physical and psychological distress, and lead to social isolation and depression. Explanation on the consequences of NIHL used to create awareness, and motivation for patient to protect their hearing by proper use of earmuffs,
earplugs and other protective devices. Patient strictly advised, for consistent and correct use of hearing protection device and limit daily activities that expose them to high noise. As mentioned by Berger [22], effective training has motivated individuals to adopt hearing loss prevention behaviors.

Those patient that severely affected and bothered by their tinnitus problem, a thorough counseling using cognitive behavioral therapy (CBT) method given to them. This approach is to gradually distract their mind from thinking or focusing on the presence of tinnitus and engaged themselves to their daily activity. Apart from that, sound therapy, or hearing aid is preferential choice given to help them overcome tinnitus issues.

In some cases, if indicated, patient will be given a support letter about their current hearing status, potential damage and consequences they may face if continuously exposed to noise at their workplace. Administrative control of noise exposure may be suggested to employer, to lay out quiet workstations, and limiting employee exposure time by implementing shift work schedules, as restricted in Factories and Machinery (Noise Exposure) Regulations 1989 [17].

Individual detected with the permanent sensorineural hearing loss with significant difficulty in hearing ability will be offered for hearing aids. Hearing aid is an electronic device that will amplify the sound to and improved listening and speech comprehension of those with hearing loss [23]. Apart from that, a yearly hearing monitoring will be scheduled for patient as this will be considered as continuous yearly assessment which will provide insight on the workers motivation and awareness level for hearing protection, whereby the information not only useful for counseling, but also for any compensation claim later.

5. Conclusion

Hearing loss at industry is regarded as one of the serious problem that should be taken into consideration by the industries which carry the potential risk. Implementing engineering control at initial design stage should be prioritized by the employer as part of NIHL prevention strategy. Besides, healthcare professional, like audiologist should plays vital roles in reducing prevalence of NIHL within the industrial community and protect hearing health clinically with proper audiological management and assessment, in order to enhance the quality of life of millions of people.

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