OCCUPATIONAL HEARING IMPAIRMENT AND ITS RELATED FACTORS: A REVIEW ARTICLE

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ABSTRACT

Noise exposure is the utmost and the most preventable cause of hearing impairment, whereby some estimates that, one-third of all hearing impairment cases can be attributed to occupational noise exposure. High level of noise exposure is a significant factor for occupational-related hearing impairment and policy makers are well aware of that. Although occupational noise exposure plays an important role in determining hearing loss, there are number of studies in recent decades are suggesting various other factors are associated with hearing impairment. The main objective of this article is to discuss about those factors and its relation with hearing impairment.

Keywords: Hearing impairment, Hearing loss, NIHL, Noise exposure, Deafness, Occupational disease
1.0 Introduction

Worldwide, 1.3 billion people are affected by hearing impairment with 10% of the population are at risk of developing. Occupational noise exposure is the utmost and the most preventable cause of hearing impairment, whereby one-third of all hearing loss cases can be attributed to occupational noise exposure (Stucken & Hong, 2014). The disease is a common health hazard among the workers around the world. High level of noise exposure is a significant factor for occupational-related hearing impairment and policy makers are well aware of this. Locally, in Malaysia, various surveillance and compensation programmes are available in order to monitor workplace noise. The hearing conservative programmes (HCP) under the Factories and Machineries (Noise Exposure) Regulations 1989, is one of the programme to prevent Occupational Noise-induced Hearing Loss (NIHL) by its seven elements.

Although occupational noise exposure plays an important role in causing hearing impairment, there are number of studies in recent decades are suggesting chemicals, largely the heavy metals and pesticides are associated with occupational-related hearing impairment (Choi, Hu, Mukherjee, Miller, & Park, 2012; Hoshino, Pacheco-Ferreira, Taguchi, Tomita, & Miranda, 2008; Hwang, Chiang, Yen-Jean, & Wang, 2009; Mac Crawford et al., 2008; Shargorodsky, Curhan, Henderson, Eavey, & Curhan, 2011). The contribution of these heavy metals and pesticides towards hearing impairment of exposed workers are often masked by the presence of noise element, whereby in most of the cases, noise is considered the sole culprit (Sliwinska-Kowalska, 2008). Contrary to this, few researchers have found that heavy metals and pesticides exposure during work may intensify the effect of noise in causing hearing impairment (Johnson & Morata, 2010; Sliwinska-Kowalska et al., 2005; Vyskocil et al., 2012).

Similarly, there are many other factors which contribute to occupational-related hearing impairment apart from noise alone. Whether directly or indirectly, these factors are also very significant in relation to hearing impairment and in this article, they will be discussed in detailed.

2.0 Socio-demographical factor

These factors are widely discussed by various journals and articles. A retrospective cohort study involving 1 million industrial workers in the USA in the year 2013 and their respective audiograms were evaluated. The study revealed that the risk of hearing impairment increases as the age advances (Masterson et al., 2013). Add to this, another publication also concluded that hearing impairment are more prevalent at third and fourth decades of life (Agrawal, Platz, & Niparko, 2008). In Malaysia, a study conducted by Masilamani et al. (2012) in a group of pesticide applicators from Negeri Sembilan in the year 2008 showed 3-fold increased risk of developing occupational noise-induced hearing impairment is evident in the workers who are more than 40 years old with the odds ratio (OR) of 3.45. In another study showed that workers who are more than 40 years old had 4 times higher incidence in acquiring hearing impairment (Nasir & Rampal, 2012).

In terms of gender, the prevalence of hearing impairment among these noise-exposed populations are more evident in male workers (Masterson et al., 2013). An author had also
mentioned that occupational noise-induced hearing impairment is the most common occupational health issue whereby it produces about four million disability adjusted life years (DALYs) with men taking the lead compared to women (Nelson, Nelson, Concha-Barrientos, & Fingerhut, 2005). Apart from this, a research on hearing impairment and its demographic factors which was conducted among 5742 US adults population also gave higher prevalence in males compared to females (Agrawal et al., 2008).

Education level of a worker also found to be significant in relation to the development of hearing impairment. A retrospective cross-sectional study which was conducted in Guangzhou, China from September 2011 until September 2012 revealed different level of education gives good result associated with hearing impairment. Overall the study concludes that higher education level found to be associated with lower risk for occupational noise induced hearing impairment (Huang & 黄羽张, 2012). Apart from that, the study by Yuri Agrawal et al. (2008) also noted to have higher prevalence among low educated population (Agrawal et al., 2008).

3.0 Personal Protective Equipment (PPE) compliance

Personal Protective Equipment (PPE) is situated at the lowest rank in the hierarchy of hazard control due to the compliance factor. In a study on compliance of Hearing Protective Device (HPD) among textiles industry workers in Pakistan, only 25% workers were using HPD constantly (Ashraf et al., 2009). Another study done in India revealed that only 28% workers were using hearing protection devices (Bedi, 2006). The compliance rate was slightly higher in Malaysia, whereby 49% of total 97 quarry workers from North-eastern state of Malaysia were compliant to HPD (Ismail, Daud, Ismail, & Abdullah, 2013). This indicates the attitude of the workers towards HPD and their level of compliance.

Employees with already defected ears are known to have a lower hearing level to environmental sounds, hence putting them to higher risk for hearing impairment. These workers must give more attention towards the HPD compliance compared to normal hearing workers (Morata et al., 2005).

These values show that controlling the risk is a very important element in preventing hearing impairment, and compliance to HPD is definitely has a significant role in combating occupational noise induced hearing impairment. This is not applicable only to the workers, but employer also should provide a proper HPD which is in good condition and do a regular maintenance check (Zalewski, 2006). Providing a hearing protective device is an important element of Hearing Conservative Program (HCP) in Malaysia whereby industries and organizations which are dealing with noise need to comply with this act. A study by Nor Saleha & Noor Hassim (2006) showed that among 167 industries, 92.8% provided a proper hearing protective device to their workers (Nor Saleha & Noor Hassim, 2006).
4.0 Chemical Exposure

4.1 Organophosphate

Organophosphate exposure has shown higher prevalence of hearing impairment (Hoshino et al., 2008; Teixeira, Augusto, & Morata, 2003). In a different study in a group of farmers has shown a constant exposure of organophosphate had resulted in the development of permanent, bilateral hearing loss (Crawford et al., 2008). However, a study among insecticide manufacturing workers found no significant association between hearing loss and organophosphate pesticide (Ernest, Thomas, Paulose, Rupa, & Gnanamuthu, 1995).

4.2 Plumbum (Lead) and Cadmium

A study conducted in the USA suggested that chronic low-level plumbum exposure is an important risk factor for hearing impairment and the risk can be prevented by reduce its exposure (Park et al., 2010). The author has mentioned that low level plumbum contact can cause defect at inner ear receptor cells and the neuronal function of the auditory system. A similar experiment studies also mentioned that plumbum can induce degenerative changes at the second part of the auditory system and delays the Vestibulo-cochlear Nerve conduction (Jones et al., 2008). Similar study in the population of the USA also revealed that influence of lead and cadmium even at very negligible level also can produce a significant effect in causing hearing loss (Choi et al., 2012). A case-control study on the relationship of hearing function and blood concentrations of plumbum, manganese, arsenic, and selenium also revealed a positive relationship of plumbum in impairing the hearing ability (Chua et al., 2007). This phenomenon is not only limited to acute plumbum exposure. There is an article mentioned about the bone-lead toxicity, whereby it has said that lead can accumulate in the bones of previously exposed adults (commonly elderly group) and stays for many years, which later can be released into their blood stream causing toxicity to nervous, auditory and cardiovascular system (Hu, Shih, Rothenberg, & Schwartz, 2007).

Besides plumbum, few studies published about a decade ago suggested that cadmium is a harmful substance to auditory organs, whereby accumulation of this toxicant may result in dose-depending hearing loss (H. Ozcaglar et al., 2000; H. U. Ozcaglar et al., 2001). This study also revealed that hair cells of ears are sensitive to cadmium. Another study revealed that apoptosis and inner ear receptor cells alterations are due to cadmium entry (Choi et al., 2012). Apart from that, cadmium absorption in intestine is enhanced with zinc deficiency (Bernhoft, 2013). In a different experimental study on rats, noted that cadmium causes the auditory threshold shift by altering the enzyme mechanism (Kim et al., 2008).

4.3 Zinc and Its Relationship with Cadmium

Zinc and cadmium are competitive binders of the Carbonic Anhydrase enzyme which is present in inner ear cells of auditory system with cadmium having higher enzyme affinity compared to zinc (Sterkers, Ferrary, & Amiel, 1987, 1988). Lower zinc concentration in the body with increased exposure of cadmium may increase the cadmium toxicity in the inner ear cells, by changing the perilymph and endolymph chloride content ultimately leading to hearing impairment (Dobson & Organization, 1992; Dwyer, Zhuang, & Smith, 1991; Sterkers et al., 1987, 1988). Add to this, generally cadmium absorption in intestine is greatly enhanced in the presence of zinc deficiency (Bernhoft, 2013). Another animal study showed that,
addition of zinc supplement into regular diet with the presence of cadmium-related ototoxicity may reverse the cadmium effect on inner ear cells and ear ossicles, hence preventing hearing impairment (Agirdir et al., 2002). Another human randomised clinical trial showed zinc supplementation has significant anti-oxidant and anti-inflammatory role in reversing Sudden Sensory-neural Hearing Loss (SSHL), giving rise to a new option to the ENT clinicians (Yang, Ko, Peng, & Hwang, 2011). However, contrast to that, another randomised study to determine the similar objective noted no significance benefits of zinc supplementation in SSHL management (Hunchaisri, Chantapant, & Sirirattanapan, 2015).

4.4 Selenium and Its Relationship with Plumbum (Lead)

Selenium is a type of minerals which can be found mainly in drinking water, whereby the sources being from the discharge from petroleum and metal refineries be it either from erosion of natural deposits or discharge from mines. Although few, but there are studies relating selenium as a protective elements towards preventing hearing impairment. There are many animal studies have been done, whereby high blood selenium has been related in reducing plumbum toxicity (Nehru, Dua, & Iyer, 1997). A case control study had shown that increasing selenium concentration in the blood has a protective function towards auditory function (Chuang et al., 2007). Apart from that, selenium acts as an effective anti-oxidant on plumbum-induced oxidative stress (Stadtman, 2002).

5.0 Smoking exposure

In a similar occupational noise exposure environment, a smoker has higher risk of becoming deaf compared to a non-smoker (Mohammadi, Mazhari, Mehrparvar, & Attarchi, 2010). In a different study with a population of 504 wagon manufacturing company employers showed higher hearing impairment cases detected among smokers in comparison to non-smokers (El Zir, Mansour, Salameh, & Chahine, 2008). These increasing risk among smokers is attributed to the components of chemical content of cigarettes. As mentioned in the earlier paragraphs, Plumbum and Cadmium are two important heavy metal components which are linked towards hearing impairment. During each smoking episodes, around 11% of the plumbum in cigarettes enters the lungs and this chemical component has relationship towards causing hearing impairment (Mannino, Homa, Matte, & Hernandez-Avila, 2005). It is known that a smoker who smokes 1 pack per day are prone to get the effects of radiation which is equivalent to one third of Plumbum-210 (Papastefanou, 2009). Blood plumbum toxicity not only confined to direct smokers, but also affects the passive smokers. Another study by (Apostolou et al., 2012), second-hand smoking is evident in contributing high blood plumbum level and the study also suggested that inhalation of the smoke is the main route. Apart from these, smokers have an additional risk of cadmium exposure, as cigarette being the important source of cadmium exposure (Bernhoft, 2013; Lin, Caffrey, Chang, Dowling, & Lin, 2010; Matsunaga, Agaku, & Vardavas, 2014; Pappas, Fresquez, & Watson, 2015).
6.0 Conclusion and Recommendation

Besides noise exposure, there are several other factors are contributing towards occupational-related hearing impairment. There are some variables such as age, gender and existing education level are non-modifiable factors which are difficult to alter. However, factors such as compliance level towards PPEs, smoking habits, organophosphate, and plumbum and cadmium exposure are modifiable, therefore proper preventive measures can be derived. Contrary to all the risk factors, the presence of blood minerals, such as zinc and selenium may play a protective role towards preventing or reducing hearing impairment occurrence. Therefore it is recommended that this information should be welcomed and considered for further research in our local populations.

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Declaration

Author(s) declare that all works are original and this manuscript has not been published in any other journals.

Authors’ contribution

Author 1: Idea conceptualizing, literature review, drafting the final manuscript, publication

Author 2: Advice and guidance during manuscript preparation

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