From ISO 1999 to noise policy

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INTRODUCTON

Noise pollution is a pervasive byproduct of industry and densely populated regions, impacting the quality of life, both socially and medically (Alberti 1998). Almost 25 % of Europe's population is exposed to transportation noise exceeding 65 dBA, determined as 24 h average energy equivalent noise. In some countries more than one half of the population is exposed to transportation noise (Hinchcliffe 1998). When environmental noise exceeds 65 dBA, sleeping is disturbed and the quality of waking hours compromised. Levels exceeding 85 dBA can cause hearing loss. Both in the United States and Europe, 30 million people are exposed to potentially hazardous levels of noise. Approximately 400 to 500 million people are at risk of developing noise-induced hearing loss (NIHL) (Alberti 1998).

NIHL is considered to be one of the most common occupational health hazards of any country. There are no global figures available for the prevalence of NIHL. Such figures, if they did exist, would lack validity in a rapidly changing industrialized world (Alberti 1998).

When NIHL is moderate to severe, it leads to speech distortion, reduced word discrimination, increased noise intolerance and tinnitus. Reduced oral communication is a social handicap (Ward 1986). NIHL also reduces the perception of warning signals, environmental sounds and music. Consequently, NIHL may lead to social isolation, decreased worker productivity and morale, and an increase of job-related accidents (Ward 1986).

The International Organization for Standardization (ISO) published in 1975 a standard for assessing occupational noise exposure for hearing conservation (ISO 1999 (1975)). The version was updated in 1990 The ISO-model (ISO 1999 (1990)) uses three input parameters: age, exposure to noise, and gender in the evaluation of NIHL. Exposure to noise is evaluated using the equal energy principle. Based on these parameters the distribution of NIHL can be calculated. The variation is large; for men the difference between 10 % and 90 % percentile of hearing loss is 60 dB when the subjects are exposed to a noise level of 100 dBA for 30 years. According to the ISO-model women are somewhat less vulnerable to noise than men. The large variation has been explained by several factors like pitfalls in the equal energy principle, other noise exposure, confounding biological and environmental factors and individual susceptibility factors (Borg 1992; Campo & Lataye 1992; Pyykkö et al. 1988).

According to ISO 1990 there are two components responsible for the deterioration of hearing: the age related component and noise exposure related component. According to the standard the age related component (presbyacusis) is more important than the noise exposure related component until the daily exposure is 90-95 dB. In the standard these components are additive, which suggests that people that are susceptible to noise have an increased risk of hearing loss even without noise exposure.

The ISO 1999 (1990) predicts the distribution of audiometric results in large populations. Audiometry is the gold standard in the evaluation of hearing loss. However the

correlation of the audiogram with subjective evaluation and handicap varies between 0.2 and 0.5 (Barrenäs & Holgers 2000). There is no prediction model to other hearing symptoms like tinnitus. Its prevalence is not correlated to audiograms (Toppila et al. 2011).

Nevertheless poor audiometric results indicate problems with hearing (Sataloff & Sataloff 1993). In Finland less than 10 % of the workforce is working in conditions where the noise exposure exceeds 85 dB. Provided that the ISO 1990 model is generally applicable, the number of working people with hearing handicap due to presbyacusis is greater than the number of working people having hearing loss due to noise-induced hearing loss. Thus to reduce the number of people with hearing handicap it is necessary to reduce the impact of presbyacusis component in the ISO 1999-model.

The presbyacusis component is due to genetic factors and lifestyle factors (Nosocusis). This is why the presbyacusis component can be reduced. For example musicians (Toppila et al. 2011) and army pilots (Kuronen et al. 2004) have smaller presbyacusis component and smaller susceptibility to noise than ISO 1999 predicts.

Factors affecting presbyacusis and noise susceptibility are as follows:

1: Diseases

The following diseases are correlating with hearing loss (Pyykkö et al. 2007)

- Otitis in childhood (at least 3 attacks)

– Otitis as adult (at least 3 during the last year)

– Chronic Otitis (duration over 3 kk)

2: Nosocusis

It has been shown that elevated cholesterol, elevated blood pressure, use of painkillers and smoking increase the probability of hearing loss ((Toppila et al. 2000, 2001; Starck et al. 1999). When several of these factors exist the may mask the effect of noise completely (Toppila et al. 2001; Pyykkö et al. 1989). The effect of single factor may be small but in combination it becomes visible (Toppila et al. 2001; Pyykkö et al. 2007). The most important single factor is the young age cholesterol with risk ratio 7.2 (Pyykkö et al. 2007).

In addition there are other factors like skin pigmentation (Barrenäs 1998; Royster et al. 1980) may have an effect to noise susceptibility. Also mandatory military service causes hearing losses in Finland (Savolainen & Lehtomäki 1996).

Provided that the presbyacusis component can be reduced the probability of hearing loss can be reduced by 30 %.

The European legislation recognizes as the only means the reduction of noise exposure. This can be done by reducing the noise levels at workplace with technical means or by using hearing protective device (HPD). Several authors have questioned the efficiency of the HPDs based on the field attenuation results (Berger 1983; Casali et al. 1991). Maybe the most important factor is the poor usage rate. Toppila et al. (2005) found that the percentage of always users varied between 30 % - 95 % in shipyard, forestry and paper mill industry. The lowest percentage was found in paper mills where the noise levels were the lowest ones. This indicates that reduction of noise level in work may even increase the prevalence of noise induced hearing loss if

the usage rate decreases faster than the noise exposure. Morata et al. (2005) have studied why HPDs are not used. The HPDs makes difficult to hear what is happening. This is especially true for workers with hearing handicap.

THE IMPACT OF NOISE ON SOCIETY

Although noise induced hearing loss (NIHL) is the most common occupational disease, it seems to have no major impact to the society. There are no sick-leaves and very few work disability cases due to hearing loss (HL). The reason for this contradicting result is that HL has an impact on other things like:

1. unemployment
2. mental symptoms like depression
3. increased accident risk.

When recording these things, the HL is seldomly mentioned in the statistics.

We live in a communication society. Today over 80 % of workers need communication skills at their work. This is true also for work in noisy environment. Hearing handicap causes communication in background noise difficult. Thus working in the factory floor or in open offices may become difficult and eventually a cause of long-term unemployment. In a Danish study (The Danish Institute for Social Research, 2003) the unemployment of those with hearing handicap is four time higher than those with normal hearing.

In daily communication subjects HL experience disabilities in communication when they are facing less than ideal conditions, for example, on a phone, varying levels of background noise, reverberant rooms, and in group conversations (Hallberg & Barrenäs 1993; Hétu et al. 1993). Because the onset of hearing loss is deceptive, people tend to avoid these disabling situations. In the long run this avoidance process results in changes in the lifestyle of people with hearing impairment (Hallberg & Carlsson 1991). The resulting handicap caused by HL affects the social and family life in different ways. The partner of a person with HL needs to pay attention when communicating with the impaired family member. The verbal contact should be performed under visual conditions and the information content must be confirmed. The handicap affects the unimpaired family member by forcing them to keep the conversions brief. Other consequences may include setting higher volumes when watching television or listening to music, loud speech and the increased social dependence of the impaired partner (Hétu et al. 1993).

These factors become more and more important as the working force is getting older. In USA the Bureau of Labor Statistics projects that there will be 40 million workers over the age of 55 by 2018 (Toossi 2009). By this time, workers aged over 45 are projected to constitute almost 45 % of the total workforce. One-third of workers aged 65 and older reported trouble with their hearing in the National Health Interview Survey 1997-2004) - three times the number reporting visual impairment (Davila et al. 2009). In these circumstances, it will become increasingly difficult for older workers to find jobs if their performance does not match that of younger workers.

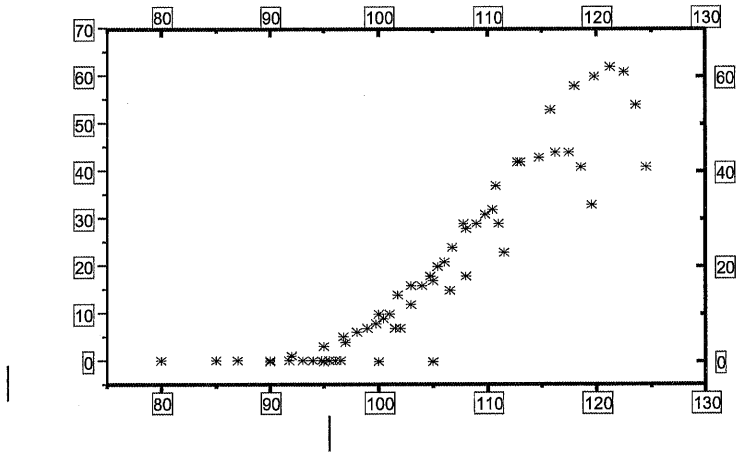

Figure 1: The probability of hearing loss according to ISO 1999 (1975) with Lex=80-110 dB. Y-axis= probability X-axis lifetime exposure

The impact of noise to accident risk is not well understood. In Canada Deshaies et al. (2008) have estimated that in 3 % of all accident noise has had a major impact the accident. It seems the workers with hearing handicap are more susceptible to accidents because misunderstandings, missing warning signal and reduced sound localisation capabilities(Toppila et al, 2009b). Accident statistics in Finland show 2-4 cases in 10 years where noise is a contributing factor to the accident.

In Sweden 32 % in working population has hearing problems (hearing loss and/or tinnitus) (Hasson et al. 2011). These symptoms are associated with stress. In Finland we could demonstrate that self-evaluated hearing problems correlates with decrease of quality of life (Toppila et al. 2008). In this study 15-25 % of workers using communication device reported difficulties at work due to hearing. About 10 % of the working population has a hearing loss. Only 20 % of these cases are related to occupational noise exposure.

Workers with hearing loss seem to disappear from the work force. This is seen from the model of ISO 1999 (1975) (Figure 1.) where the probability of HL decreases when the exposure exceeds a limit. This may be due to the fact that workers with HL have problems to do their work properly. Also people think that they are stupid. A moderate effect to mental health among young and middle aged workers has been reported (Tambs 2004).

This justifies making a model where people with hearing loss have an increased risk of early removal from the work force (Figure 2). As this removal happens through unemployment, accident and mental problems there is seldom notification about the HL which is at least a contributing factor to the removal.

In Figure 2 are given some estimated figures how removal from workforce can occur. Early retirement refers to cases where poor hearing causes stress, or difficulties at work, which makes the subject willing to retire as soon as possible. In the lower right corner are some estimates about the statistics. Applying the ISO 1999 (1990) model to the Finnish criteria of Noise Induced Hearing Loss, it can be estimated that the number is 30 % too high. On the other hand only for half of the people with non-occupational HL there are data available about audiogram. This data is never transferred to the cause of retirement or unemployment.

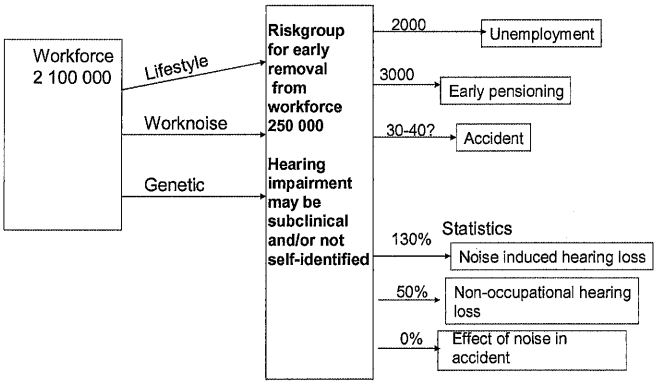

Figure 2: Causes of hearing loss, removal from the active workforce and official statistics

DISCUSSION

In this paper we have examined environmental factors affecting to hearing and the impact of hearing loss in work life. Noise causes hearing loss but also it makes the life difficult to those with hearing loss. Pejtersen et al. (2011) have shown that in open offices there are 62 % more absences than in traditional offices. Noise, ventilation and spreading of infection are the most probable explanations according to the study. If this is true noise can cause sick leaves, but still they do not show up in the statistics as noise induced sick leaves. The same problem applies to early retirement where noise and/or hearing loss are involved. We may only estimate the order of magnitude of the problem.

The fight against HL must be started early. Ear infections in the kindergarten is the first point where an intervention can be made by vaccination. This has started in Finland in 2010. Next interventions should be started when people are in the age of 12-15 years. At this age correct attitudes towards hearing protection are easy to develop (www.dangerousdecibels.org). Also this is the time to have an impact to the free-time noise exposure and the best time to promote healthy lifestyle, which prevents nosocusis.

For working people there are three possibilities

- hearing protection for noisy workplaces
- workplace design to take into account HL
- improving personal solutions for people with mild HL.

Only the first possibility is mandatory by law. For workplace design there exist good methods, but maybe the need is not fully understood. At workplaces where communication needs are complex, the personal solutions should be developed even for people with subclinical HL. There is a performance limitation of hearing aids and the social stigma associated with their use, particularly for workers with mild hearing loss characteristic of that associated with aging (Kochkin 2007).

Finally something should be done to understand the relationship between HL, unemployment and mental disorders. However this seems to be the most difficult part. The protection of privacy makes it almost impossible.

CONCLUSIONS

Noise is an underestimated problem in our society. Modern work sets needs for communication even in difficult conditions like factory floors and open offices. Back-

ground noise is not regarded as a health hazard because there are no good ways to evaluate its effects. The background noise seems to be difficult especially for those with hearing impairment. Nowadays only the effects of noise to hearing are evaluated. A much broader approach, which includes the effect to communication and other health effects, is needed.

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