Noise Exposure and Hearing Status among the Registered Locksmiths in Tehran, Iran

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ABSTRACT
Noise is one of the most common workplace hazardous agents that can cause permanent hearing damage. Workers in many industries are usually exposed to noise levels with high risks of hearing loss. Accordingly this research aims to study the noise exposure and hearing status of registered locksmiths who are exposed to harmful effects caused by several factors, such as key making machines loud noises. This study has been carried out in 33 key workplaces in Tehran capital city of Iran. In order to eliminate the effects of background noise, two different measurements were carried out in the same field conditions by taking in and out of key making machines. The overall sound level and octave band of noise analysis of the key making machine, during the process of Right and Left Shift Gears by considering the background noise level during off time of the machine was determined using ISO 9612 standard method. Hearing threshold of locksmiths is also determined using the NIOSH standard method. Based on results, average of right and left groove keys scraping processes and background noise levels were 92.9, 96.2 and 66.5dBA respectively. The mean noise exposure time of locksmiths was 0.2 h/day. So, the amount of the workers noise equivalent level was found to be 77.63 dBA which is lower than the ACGIH threshold limit values. The results of audiometric tests also showed no significant hearing loss among locksmiths, something can be explained by their low noise exposure levels. It is suggested to assess hearing response of the workers by other methods like ABR.

Keywords: Key maker, Noise exposure, Hearing loss, Locksmiths

INTRODUCTION
Considering the technology and science advantages as well as use of various equipment and tools in the cycle of production is leading to exposure of workers to the hazardous factors like noise therefore attention to the occupational health of workers seems the most important matter in industries [1]. Incidences of noise induced hearing loss [NIHL] have been associated with workers exposed to noisy environments [2]. Based on the researches a large number of workers are exposed to unsafe level of noise, which could cause some hearing injury or even serious hearing loss in work places [2]. Man et al. in 1982 stated that 16% of workers globally suffered from hearing loss as a result of noise exposure [3]. More than 30 million workers [almost one out of ten workers] are exposed to unsafe noise level in work places in USA [2]. Conducted research in over 3 year periods study on more than 200 workers from 90 various industries in Cyprus shows that 27.8% of these samples suffered from some hearing damage while
7.7% of the samples suffer from serious hearing loss [2].

There is direct relationship among age, work experience, duration of daily work shift and reducing hearing ability [4]. Another research in 1109 workers of various industries in Hamadan and Malayer cities indicate hearing loss average of 34.42 dB (A) with 24.72 SD [4]. There is a correlation and relationship between threshold of hearing loss and measuring equivalent sound levels in studied workers of Tehran's milk factory [5]. Working in a noise polluted places has correlation with hearing loss (age and gender independent)[6].

ALtinoze et al. in 2001 performed a research on high speed drill and its results confirm the ability to cause hearing loss [7]. Another research on 137 dentists and 80 physicians indicated better hearing levels in physicians compared to dentists especially in 4000Hz central octave band frequency. It was also found that left ear of right handed dentists had more hearing loss that was related to dentist's postures and lower distance between left ear and the noise source. Finally this research indicated an effective relationship between hearing loss and using dental high speed drill [7]. The high speed drills also cause hearing losses in high frequencies so that with the increase in age and job history, hearing loss in conversational frequencies will be more significant [8]. While some investigation against mentioned results has stated that dental high speed drill has no risk for dentists at all [9].

According to conducted extensive literature review there is no information about key making machine noise characteristics and its probable hearing loss effects on its users key making is a noisy process because of using scrabbling machine. The objective of this study was to measure the noise in key making working environment and its effects on workers hearing status.

MATERIAL AND METHODS

Noise exposure and hearing status of the locksmiths in Tehran Capital city of Iran was considered in a cross sectional study. The number of locksmiths and their distribution in Tehran was collected by preliminary research using various available resources in Iran. The locksmiths in Tehran are in two categories including, registered stationary locksmiths and non-registered mobile locksmiths. There is no exact data about the mobile locksmiths. So this research was only carried out on Tehran's registered stationary locksmiths with overall population of 515. A Pilot study was carried out and using statistical methods, the number of sample determined to be 30 by 95% confidence. In this case 33 males were randomly chosen as a case group. In order to match up the numbers, the same amount of male workers was selected as control group who were exposed to background noise level with no machine's noise exposure. Initial statistical analysis showed no significant differences between the case and control's age.

The overall workplace noise level and its characteristics in octave band centre frequencies were determined. The noise measurements were based on the ISO 9612 standard method [ISO 9612, 2009] and also the measurements were carried out at A-weighted network using calibrated sound level meter, model Cel – 480. The equivalent A-weighted sound levels (Leq) for Right and Left gears key were measured.

The A-weighted equivalent continuous noise level was then calculated by the following method:

\[
L_{eq} = 10 \log_{10} \frac{1}{T} \left[ t_1 \times 10^{L_1/10} + \ldots + t_n \times 10^{L_n/10} \right] \]

Where:
- \( T \) = the Total exposure time
- \( t \_i \) = the exposure time with sound level of \( L \_i \)
- \( L \_i \) = the measured equivalent A-weighted sound pressure levels

In this study locksmiths are exposed to noise either when the key making machines are running or the time they are off background. So the problem reduced to two different conditions composing background and total noise, so the above equation is reduced to:

\[
L_{eq} = 10 \log_{10} \frac{1}{T} \left[ t_1 \times 10^{L_1/10} + t_2 \times 10^{L_2/10} \right] \]

Where:
- \( t_1 \) : the exposure time to total noise
- \( t_2 \) : the exposure time to background noise
- \( L_1 \) : the measured total equivalent A-weighted sound pressure levels
- \( L_2 \) : the measured background equivalent A-weighted sound pressure levels

In order to find the exposure time to total noise (\( t_1 \)), the number of stretches of working with the machine are multiplied by the total running time of the machine. The machine is turned on for about 30 seconds, each time that a worker makes a key, and 50 keys are made during the time of shift, the total time of exposure becomes:

\[
50 \times 0.5 = \frac{25}{60} \approx 0.4 \text{ hr/day}
\]

So the total time of background noise exposure can be found by subtracting the total time of worker attendance in their working place by the result of above calculation. Both sound levels including total and background were measured by the same above mentioned method and locations with just truing on and off the machine.

Two different process of key making including Right and Left Shift Gears are also considered in the
measurements. Figs 1 and 2 show a typical key-making device along with right and left gear keys.

In order to achieve accurate results, audiometric tests were done at the beginning of the work shift. The hearing threshold limits, then in different frequencies of left and right ears were measured by Ac40 clinical audiometer in a silent room. Then constant noise induced hearing loss were calculated for right and left ears by using the equation below after presbycusis loss correction [12]:

\[ \text{NIHL} = \left( \frac{\text{HL}_{1000Hz} + (\text{HL}_{1000Hz}) + (\text{HL}_{2000Hz}) + (\text{HL}_{4000Hz})}{4} \right) \] (3)

Where:

- HL: Hearing Threshold Limits in different frequencies (dB)
- NIHL: Noise Induced Hearing Loss (dB)

Then the total NIHL is calculated by the equation below:

\[ \text{NIHL}_t = \frac{(\text{NIHL}_b \times 5) + (\text{NIHL}_p)}{6} \] [14]

In which:

- \( \text{NIHL}_t \): Total Noise Induced Hearing Loss of both ears (dB)
- \( \text{NIHL}_b \): Noise Induced Hearing Loss of ear with better hearing (dB)
- \( \text{NIHL}_p \): Noise Induced Hearing Loss of ear with poor hearing (dB)

The data was analyzed by ANOVAs test using SPSS software.

**RESULTS**

**Noise measurements**

The overall mean worker's background noise and 8-hour sound equivalent level were found to be 72 dBA and 81.5 dBA respectively.

The average A and C weighted and one octave band sound pressure levels near the device were compared for right and left key gear processing and the results are shown in Table 1 and Fig 3.
According to Table 1, the average A and Lin weighted sound level for the process of left key gear in dBA and dBC were found to be 98.9 and 98.3, respectively, and for the right key gear, the data is 92.4 and 92.6, which means left key has a higher noise level than right key, although in general, there is not a significant difference between these data. As it can be observed in Fig 3, the maximum and minimum of the sound equivalent level for left key gear at the workplace were 90 and 80 dB, respectively. This result for right key gear, however, was found to be 97 and 83 dB. This means that there is an increase in left gears key sound equivalent level compared to right one and this is due to the difference between right and left key gears, which means left key gears need higher pressure to scrap and therefore higher noise level is produced. It should be mentioned that the subjective perception of noises in both left and right gear key processes is higher than that of the measured findings. In this case, the loudness level will be 99.2 and 108.84 phones for right and left gear, respectively.

### Table 2. Noise induced hearing loss in case and control groups

<table>
<thead>
<tr>
<th></th>
<th>NIHL-Right</th>
<th>NIHL-Left</th>
<th>NIHL-Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case</td>
<td>6.94 dB</td>
<td>6.29 dB</td>
<td>5.47 dB</td>
</tr>
<tr>
<td>Control</td>
<td>5.35 dB</td>
<td>6.33 dB</td>
<td>4.61 dB</td>
</tr>
</tbody>
</table>

**Hearing Threshold**

According to Fig. 4, there is a fall in average hearing threshold right ear of both case and control groups hearing threshold at frequencies of 1000 and 2000 Hz, and also there is a highest decrease at 4000 and 8000 Hz. They also interact at the same point at 4000 Hz.

As it can be observed from the above table, noise induced hearing loss of control group in right ear is lower than that of the case group. Whereas this result does not apply for the left ear since NIHL is the same for both groups. However, in total, NIHL is higher in locksmiths. Statistical analysis showed no significant difference between hearing status of the case and the control groups, it means that the exposed noise in the range of this study is below hazardous limits.

Cases and control group left ear and right ear hearing threshold limit is also shown in Fig 5 and 6, separately which they also prove the above statement.

Fig 7 also shows left ear’s HL and NIHL and as it observed from it HL has higher hearing threshold than NIHL, but they are having same frequency track. This means that noise induced hearing loss is affected by age.

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