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## Noise Induced Hearing Loss at Two Textile Plants in Sudan

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### Abstract:

**Background:** Noise is a major health threat in occupations where the level exceeds the permissible limit (85 decibel). Noise causes discomfort or adverse health effect. The degree of negative effects of noise depends on its intensity, spectrum of frequency nature, duration of exposure and individual sensibility. **Materials and Methods:** This cross-sectional study was performed on Alhodhood and Alsabagoon textile factories employees who were exposed to noise in Khartoum - Sudan. Noise levels (dBA) were measured by sound level meter. Data was collected using questionnaire; and Pure tone air conduction audiometric test was conducted by calibrated Kamplex Diagnostic audiometer (KLD 23 mha, BSEN 60645) to determine the employees' hearing thresholds. Data was analyzed to determine the overall prevalence of hearing loss. **Results:** The highest recorded sound pressure level SPL reading at Alhodhood factory was  $88.9 \pm 2.7$  dB and  $Leq$   $88.0 \pm 6.5$  measured at the weaving section. Max p ranged from  $83.61 \pm 6.5$  to  $104 \pm 2.1$ . The highest recorded sound pressure level reading at Alsabagoon factory was  $93.8 \pm 1.7$  dB and  $Leq$   $93.2 \pm 1.1$ , measured at the preparing section flowed by weaving record  $87.0 \pm 3.0$  which were more than permissible level. Max p ranged from 92.34 to  $108.2 \pm 1.4$ . Workers at Alhodhood and Alsabagoon perceived the level of noise at their work environment is high, prevalence of noise-induced hearing loss (right ear), the highest 31.5% was among Alsabagoon workers and 14.3% among Alhodhood and noise-induced hearing loss (left ear) was 24.1% among Alsabagoon workers and 17.1% among Alhodhood. **Conclusions:** Workers in weaving section of both factories and preparing section in Alsabagoon factory were exposed to average levels of noise above 85 dBA, the major risk factors for NIHL were the duration and the level of noise exposure and hearing loss was significantly associated with working experience of more than 10 years.

**Keywords:** Noise, noise induced hearing loss, exposure, and textile.

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## **Introduction:**

World Health Organization reported that 16% of the disabling hearing loss in adults is attributable to occupational noise exposure [1]. The association between noise and noise-induced hearing loss (NIHL) has been known since the 18<sup>th</sup> century. NIHL remains among the 10 leading occupational diseases [2]. Noise-induced hearing loss usually progresses unnoticed until it begins to interfere with communication, posing a serious safety hazard and a decrease in the quality of life [3]. The following categories are widely applied because they correspond to regulatory limits in developed (usually 85 dB (A)) and many developing (usually 90 dB (A)) countries for 8-hour day: Minimum noise exposure: <85 dB (A), Moderately high noise exposure: 85–90 dB (A), High noise exposure: > 90 dB (A). [4]. Noise induced hearing loss is an irreversible and incurable disease [5]. Noise exposure can create permanent threshold shifts (PTS); temporary threshold shifts (TTS), permanent or temporary tinnitus and other physical side effects such as high blood pressure. These types of hearing damage are often referred to as noise induced hearing loss (NIHL) [6]. Noise induced hearing loss ranging from an average hearing threshold across 500, 1000, and 2000Hz of 25 dB or for OSHA [7]. The higher frequencies are more commonly the first to be damaged by the hazardous noise. Hazardous noise is generally any noise that is above 85 dBA [6].

## **Materials and methods:**

This is a descriptive cross sectional study conducted at Alhodhood textile factory and Alsabagoon Textile Company located in Khartoum North industrial area in 2013. The study included 198 workers at the two factories; medical examination of the hearing is carried out to (78) workers so many of the workers at the stage of the medical examination has stopped working because the length of the plant stops.

A comprehensive questionnaire with both open and closed-ended questions was used to collect demographic data. Measurements of sound level at all sites were done by using a Burel and Kjaer type 2203 (Integrating) Sound Level Meter .Noise Dosimeter: A personal dosimeter (model B & k type 4428, made in Denmark) was used to establish a total noise dose over eight hours of exposure on randomly selected workers from all sections at the two factories by using simple random sampling. Measurements were taken during the usual working hours at 8:00 am and 3:00 pm, when the factories were in production. Audiometric test was conducted using calibrated Kamplex Diagnostic audiometer (KLD 23 mha, BSEN 60645) to determine the employees hearing thresholds, the earphones used with this audiometer were Telephonic model TDH-50P in the conventional frequencies 0.25, 0.5, 1, 2, 4 and 8 KHz for both ears of each. The

audiometer met ANSIS 3.26-1981 standard, and calibrated in dBA. All audiometric tests were conducted in a testing facility fulfilling ISO 8253-1(1989) criteria. The background noise level in examination room was usually 45dBA (the A-weighted level was commonly used to define degrees of auditory risk) and was checked twice per day to ascertain that it remained below 50dBA, the accepted standard in many industrialized countries. Measurements were taken using 5dB increments. Audiometric tests were only made at least 18 Hrs after the last exposure to noise to allow recovery from any temporary hearing threshold shifts. Ears with conductive hearing or impacted by wax or perforated were excluded from the statistical analysis .Test was started at a frequency of 1000 Hz and then in the order of 2000, 4000, 8000, 500 and 250 Hz. The average hearing threshold of 25 dBA or more at frequencies 0.5,1,2, and 4kHz was the criterion used for hearing impairment.

The results of both tests were compared using SPSS (Ver. 21). Paired't test was used for comparison. A P-value of less than 0.05 was taken as the level of significance. An informed consent was filled for each participant.

**Results:**

**Table (1): Demographic and characteristics of participants at Alhodhood and Alsbagoon factories - Sudan - 2013 (n=187).**

| Variables    | Alhodhood |       | Alsbagoon |       | Total |       |
|--------------|-----------|-------|-----------|-------|-------|-------|
|              | No        | %     | No        | %     | No    | %     |
| Gender       |           |       |           |       |       |       |
| Male         | 56        | 64.4  | 69        | 69.0  | 125   | 66.8  |
| Female       | 31        | 35.6  | 31        | 31.0  | 62    | 33.2  |
| Total        | 87        | 100.0 | 100       | 100.0 | 187   | 100.0 |
| Age (years)  |           |       |           |       |       |       |
| 18 - 30      | 46        | 52.9  | 54        | 54.0  | 100   | 53.5  |
| 31 - 40      | 22        | 25.3  | 33        | 33.0  | 55    | 29.4  |
| 41 - 50      | 11        | 12.6  | 5         | 5.0   | 16    | 8.6   |
| 51 - 60      | 7         | 8.0   | 7         | 7.0   | 14    | 7.5   |
| More than 60 | 1         | 1.1   | 1         | 1.0   | 2     | 1.1   |
| Total        | 87        | 100.0 | 100       | 100.0 | 187   | 100.0 |

**Table (2): Noise measurements at Alhodhood Factory - Sudan - 2013.**

|                 | Leq(dBA)  | Max p     | Min L    | Max L    | Lepd     | SEL       | SPL      |
|-----------------|-----------|-----------|----------|----------|----------|-----------|----------|
| Weaving         | 88.0±6.5  | 104.2±2.1 | 86.9±2.2 | 89.2±5.6 | 87.5±2.2 | 98.3±2.3  | 88.9±2.7 |
| Administration  | 58.4±8.1  | 83.61±6.7 | 54.1±8.5 | 64.3±7.8 | 58.1±8.2 | 68.7±8.1  | 59.4±9.7 |
| Preparing       | 63.1±4.6  | 90.5±6.4  | 60.0±3.8 | 70.5±6.7 | 62.8±4.6 | 73.7±4.6  | 64.3±5.0 |
| Printing        | 77.0±2.6  | 94.6±3.1  | 75.8±2.6 | 80.0±3.3 | 77.6±3.5 | 87.35±2.7 | 77.8±2.8 |
| Quality control | 79.6±1.49 | 97.5±1.1  | 78.3±1.5 | 82.7±1.9 | 79.3±1.5 | 90.1±1.4  | 80.4±1.7 |

**Table (3): Noise measurements at Alsbagoon factory - Sudan - 2013.**

| Department | Noise level in dBA |
|------------|--------------------|
|------------|--------------------|

|                 | Leq(dBA)  | Max p     | Min L     | Max L    | Lepd     | SEL       | SPL      |
|-----------------|-----------|-----------|-----------|----------|----------|-----------|----------|
| Weaving         | 86.1±6.4  | 102.2±2.9 | 85.3±3.1  | 87.3±4.0 | 85.8±3.2 | 91.0±3.3  | 87.0±3.0 |
| Administration  | 63.6±3.5  | 92.34±5.5 | 57.4±3.5  | 74.4±6.7 | 63.9±4.1 | 75.0±3.9  | 61.8±2.8 |
| Preparing       | 93.2±1.1  | 108.2±1.4 | 92.6±1.2  | 94.2±1.2 | 92.9±1.1 | 103.6±1.2 | 93.8±1.7 |
| Printing        | 71.4±2.9  | 90.9±1.7  | 70.4±2.6  | 73.2±2.5 | 71.1±2.8 | 82.4±3.7  | 73.8±2.7 |
| Quality control | 74.37±1.7 | 93.24±3.0 | 73.18±3.0 | 76.3±3.5 | 74.1±3.9 | 85.1±3.7  | 76.5±4.1 |

Figure (1): The perceived noise levels at the work environment according to questionnaire respondents employed at Alhodhood and Alsbagoon textile factories – 2013 (n=181).

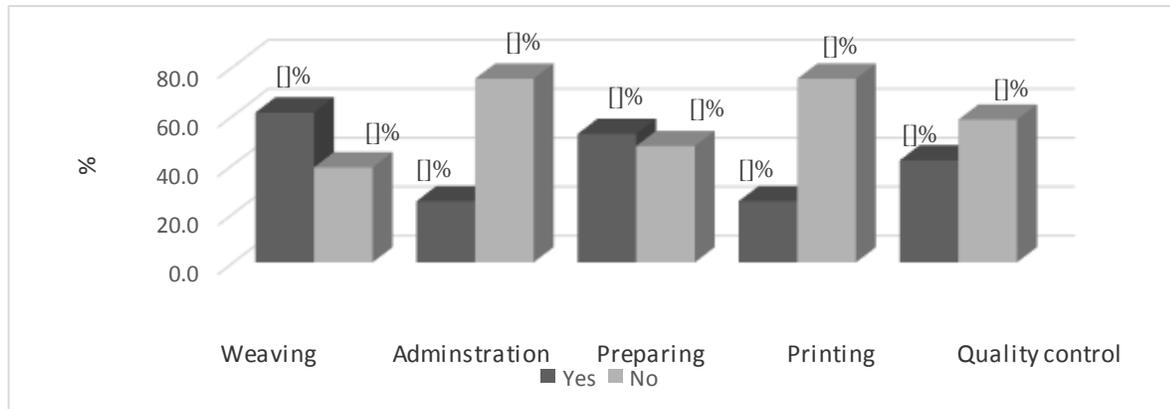
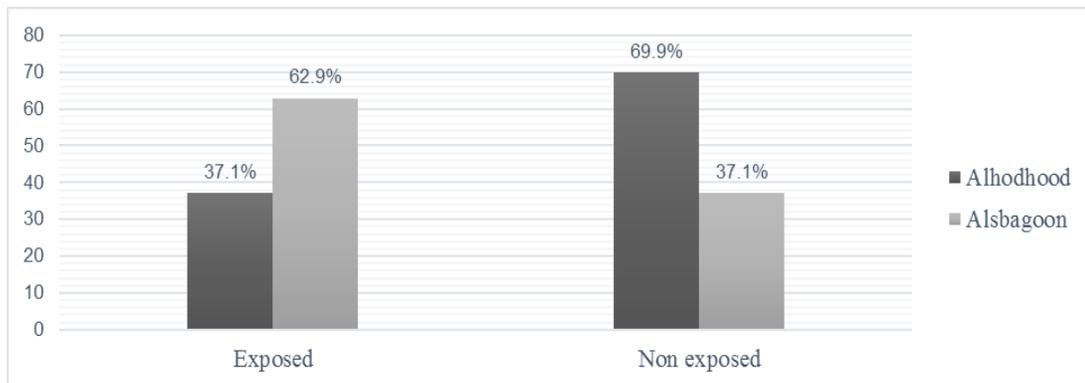
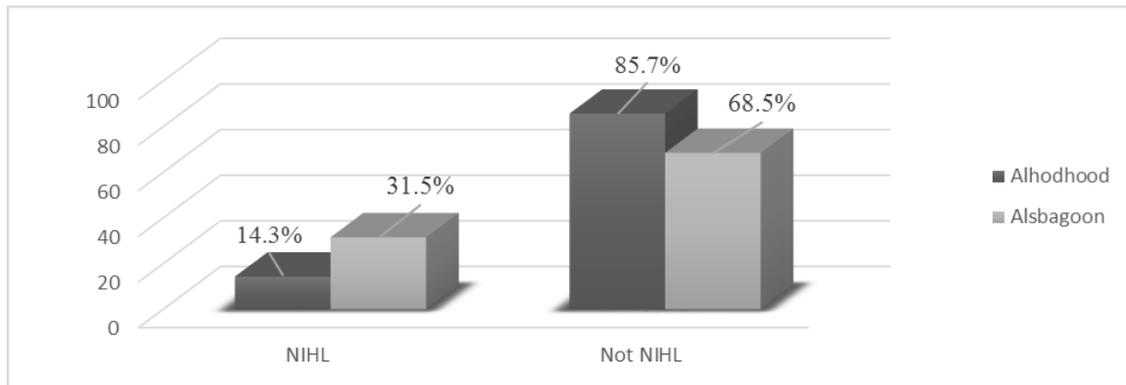


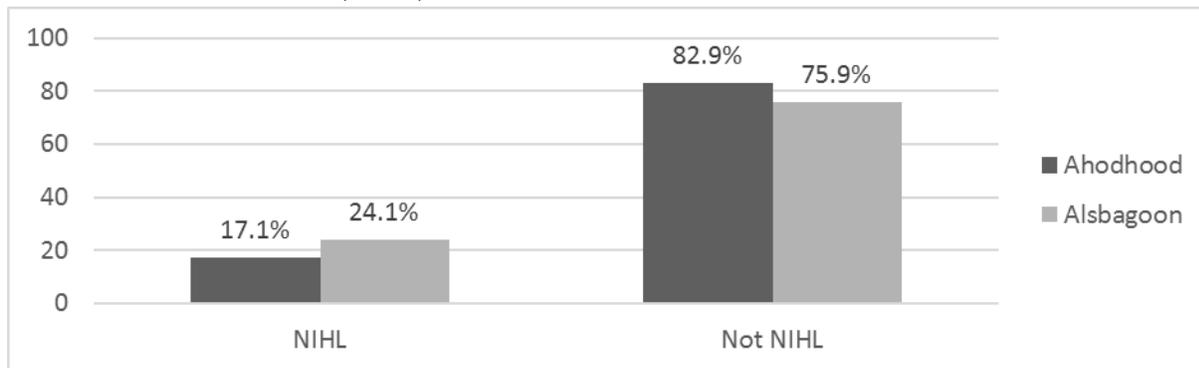
Figure (2): Distribution of employees into exposed and non-exposed according to (SPL ≥ 85 dB) at Alhodhood and Alsbagoon factories - Sudan – 2013 (n=198).



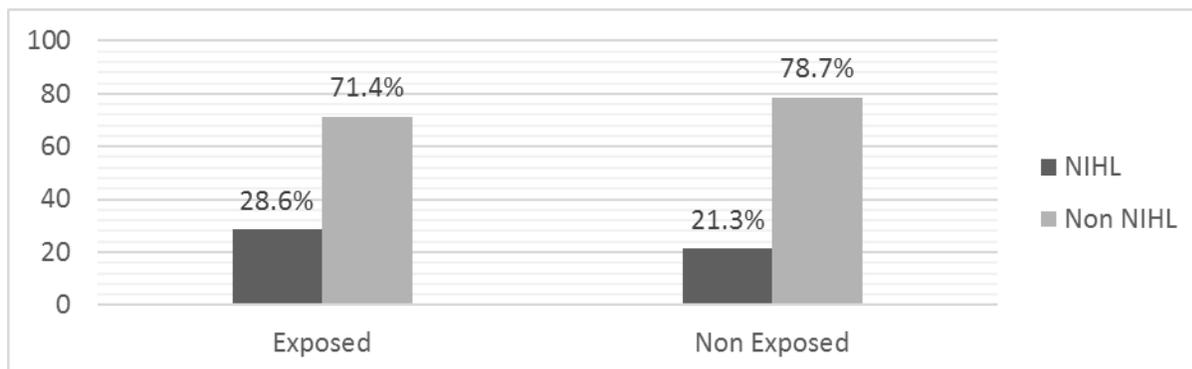
**Figure (3): Noise induced hearing loss (right ear) among workers employed at Alhodhood and Alsbagoon textile factories-Sudan -2013 (n=187).**



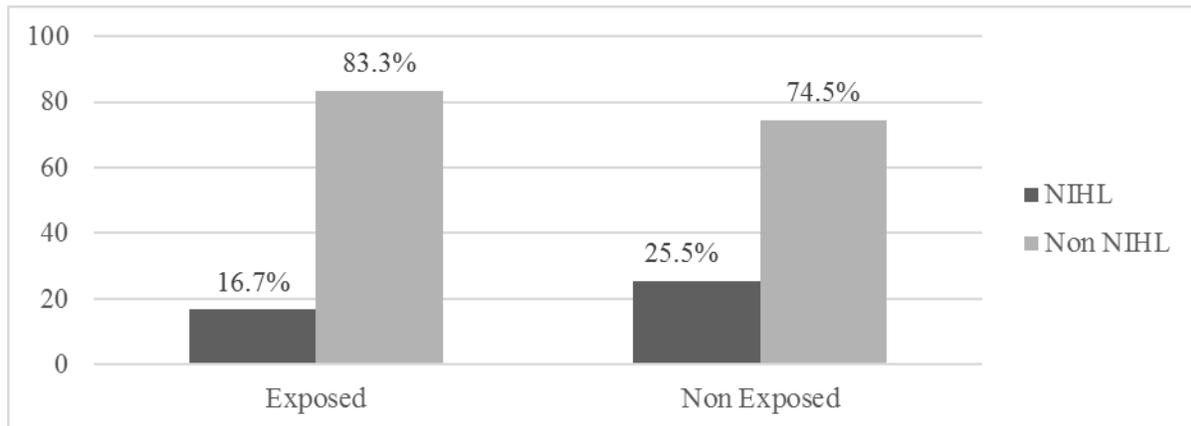
**Figure (4): Noise induced hearing loss (left ear) among workers employed at Alhodhood and Alsbagoon textile factories- Sudan-2013- (n=187).**



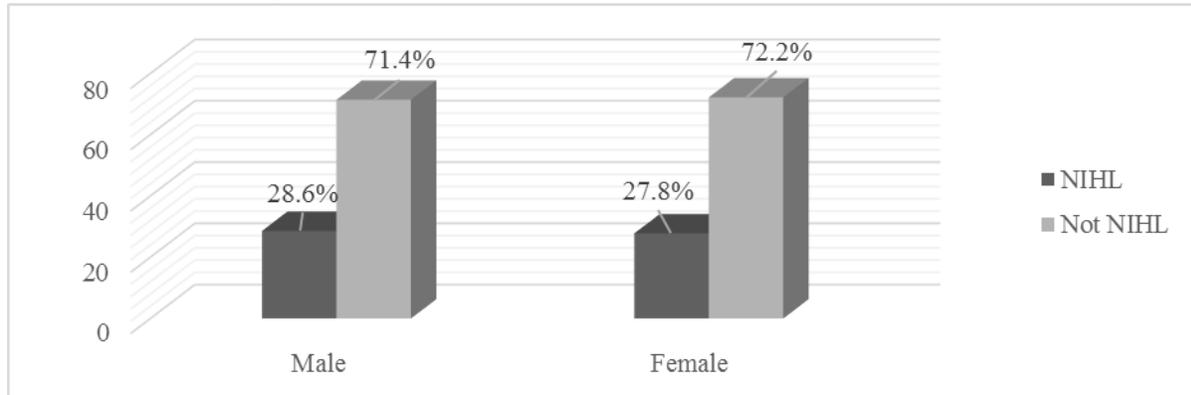
**Figure (5): Noise induced hearing loss (right ear) among exposed and non-exposed employees at Alhodhood and Alsbagoon textile factories – Sudan-2013-(n=89).**



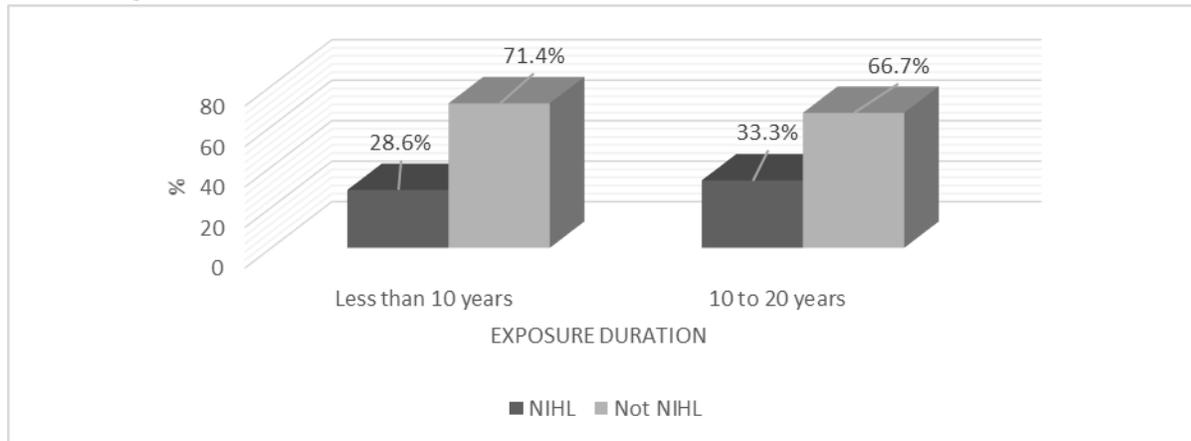
**Figure (6): Noise induced hearing loss (left ear) among exposed and non-exposed employees at Alhodhood and Alsbagoon textile factories – Sudan-2013-(n=89).**



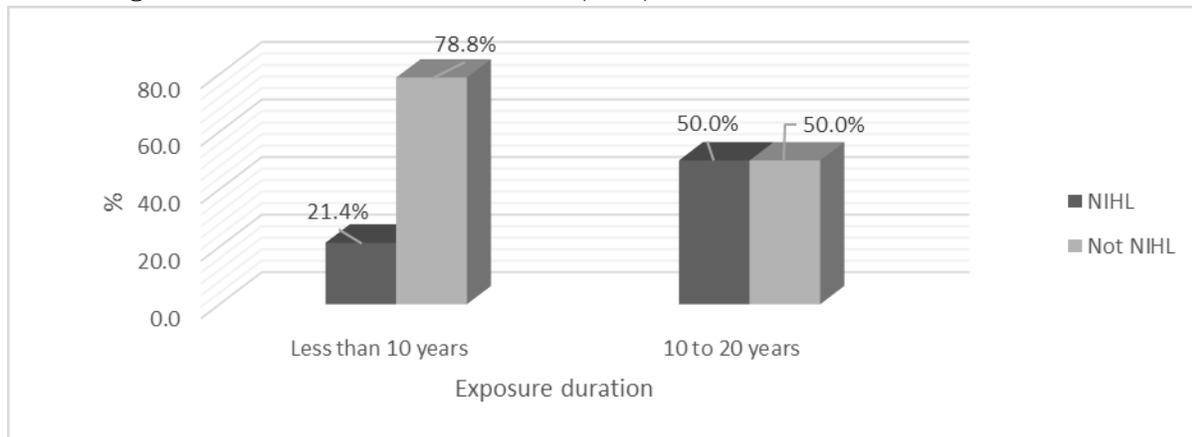
**Figure (7): The gender distribution of noise induced hearing loss (right ear) cases employed at Alhodhood and Alsbagoon textile factories – Sudan- 2013-(n =78).**



**Figure (8): Exposure duration and noise induced hearing loss (right ear) among workers at Alhodhood and Alsbagoon textile factories - Sudan - 2013 (n=78).**



**Figure (9): Exposure duration and noise induced hearing loss (left ear) among workers at Alhodhood and Alsbagoon textile factories - Sudan - 2013 (n=78).**



**Discussion:**

Results of the noise measurement show that overall noise levels dBA Leq at Alhodhood included in this study ranged between 58.4±8.1 and 88.0±6.5 dBA. Noise levels dBA Leq at Alsbagoon ranged between 63.6±3.5 and 93.2±1.1. Workers in weaving section at both factories and preparing section at Alsbagoon factory were exposed to average levels of noise above 85 dBA, the threshold limit value has been set and allowed by the International Standards Organization (ISO), EEC and other developed countries. NIOSH estimates that there is an excess risk of 8% for a 25 dB average hearing loss at 1, 2, 3 and 4 kHz at an occupational  $L_{A2000h}$  of 85 dBA and 25% excess risk at a level of 90 dBA [2]. United Kingdom, Belgium, Italy, Canada, France and Denmark allow 90 dBA Leq. Japan, Sweden, Germany, Norway allow 85 dBA Leq. These limits are allowed for halving rates of 3 dBA and working schedules of 8 h/d. OSHA (USA) allows 90 dBA for 8 h/d with halving rate of 5 dBA [8], as well as in some African countries, including Sudan [9]; and in some Asian countries including Vietnam [10]. The noise level 88.0±6.5dBA in the weaving section at Alhodhood and noise level 87.0±3.0 were comparable to the noise level at the range of 88.4 - 104 dBA level measured in weaving sections of five renowned textile industries of Karachi in Pakistan [11], 102.5 dBA in Hong Kong [12], The average noise level in the weaving sections were 101.3 ± 2.7 dBA and 89.8 ± 5.3 dBA in Thailand, respectively [13], also in Ethiopia [14] who reported that the highest noise level in area samples was observed in weaving section, with mean ±SD of 99.5 ±3.2dBA. Also (2000)[15]who reported that the noise levels range between 94 dBA and 116 dBA in a textile factory of Timisoara city i.e., they exceeded the Romanian limit of 90 dB. Also [16] who reported that workers exposed to high noise 105 dBA in a textile factory also in [8] who reported that workers at two factories in India exposed to high noise level ranged between 80 to 102 dBA.

Daily period of noise exposure was 8 hours for all of the workers in both factories. The daily noise exposure of workers in areas like weaving, quality control in both factories and preparing section in Alsbagoon exceeds the maximum exposure limit of 90 dBA, specified by occupational health Khartoum state ministry. The noise exposure at other work areas like administration section at both factories recorded less than 90 dBA, but is quite higher than limits used for assessment of noise for community response. 75% (202 subjects) from the exposed group were exposed to a daily Leq above the permissible level of 85 dBA and most (61.0%) of these did not and had never used any form of hearing protection [17]. As reported by [10] Noise in the weaving section showed that the noise levels exceeded the Vietnamese standard of 90 dBA by as much as 9 dBA in some areas and have demonstrated that [15] the noise levels ranged between 94 and 116 dB (A), i.e., they exceeded the Romanian limit of 90 dB. Exposed to continuous broadband noise of the constant level of approx. 100 dBA [18]. The study revealed that the highest noise level in area samples was observed in weaving section, with mean  $\pm$ SD of  $99.5 \pm 3.2$ dB [14]. In [11] it was shown that noise level was in range of 88.4-104 dBA. The Occupational Health Section reported that the noise level in different sections of Assiut Spinning Factory range from 85-105dBA.

Noise induced hearing loss is an irreversible and incurable disease [5]. The occupations that carry a particularly high risk of hearing loss include operation of textile machines [5]. The results revealed that the prevalence rate of hearing loss (right ear) was higher among the exposed group 28.6% and 21.3% in the non-exposed group; hearing loss (left ear) was higher among the exposed group 16.7% in the exposed group, and 25.5% in the non-exposed group. Bivariate analysis showed a significant hearing loss in the exposed vs. non-exposed subjects [17]. This study has shown that the NIHL ratio was significantly more prevalent on the exposed subjects; and that this agree with [19, 5]. Twelve of the workers (10.0%) complained of hearing loss [20]. Thirty eight percent of exposed subjects had hearing impairment, which was 8-fold higher rate than that found for non-exposed subjects [17]. The study has shown that the NIHL ratio was significantly more prevalent on the exposed workers in the weaving section at both factories compared with administration workers. For sections, the highest hearing impairment were recorded among workers in the weaving, preparing and quality control sections while the lowest levels were recorded among the staff in the administration section. The higher noise levels in the weaving, preparing and quality control sections, reflected in higher prevalence of NIHL among workers in those sections. This agree with many studies Ethiopia by [14] who mentioned that hearing impairment was highest prevalence of 71.1% observed among the weavers. No significant differences between hear disturbance and different sections of factories sector. This is attributed to high levels of noise in all sections at the two factories compare to [13] who revealed the significantly higher noise induced hearing loss among workers in the weaving section compared to other mill workers and office workers ( $P < 0.01$ ). The present study also found that

subjects exposed to daily Leq greater than 85 dBA had significantly higher mean thresholds than the non-exposed across frequencies tested. No significant differences between hear disturbance and different sections of spinning sector. This is attributed to high levels of noise in all sections at the two factories. The major risk factors for noise induced hearing loss were the duration and the level of noise exposure [14]. The Occupational Health Section reported that the noise level in different sections of Assiut Spinning Factory range from 85-105dB. The prevalence rate of hearing loss was higher among the exposed group i.e. 30.0% in the exposed group, and 8% in the non-exposed group [21]. The present study showed that the prevalence of noise induced hearing loss symptoms significantly increased in some sections such as quality control, weaving, and preparing as these sections had high noise level than other sections. The amount and type of direct hear cell damage depends on the intensity of the sound [22]. No significant differences between the hearing loss intensity in men and women were found these agree with previous study [18]. No significant difference was found between right and left ears of the exposed subjects.

The major risk factors for NIHL were the duration and the level of noise exposure. This relationship is similar to that observed in previous studies [13, 14, 23, 21, 18, 24, 11, 16, 17, and 10]. The major risk factor for occupational hearing loss is excessive noise on the job [25]. Noise is a serious occupational health hazards in the spinning factory. The major risk factors for noise induced hearing loss were the duration and the level of noise exposure [14]. Despite the high intensity noise in some sections of the company, some individual did not suffer ONIHL. This may be because different people have different susceptibilities. The present study revealed that the study subjects were in the economically productive age groups (18 – 30 years) age group (53.5%) and if they suffer from hearing disability at this age, they would have to live with that disability throughout their life. Results of noise induced hearing loss (right ear) among the workers of Alhodhood and Alsbagoon factories show that within less than 10 years 10 to 20 years of exposure; over 33.3% and 28.6% of the workers had noise induced hearing loss respectively. Results of noise induced hearing loss (left ear) among Alhodhood and Alsbagoon factories workers show that within less than 10 years 10 to 20 years of exposure; over 50.0% and 21.4% of the workers had noise induced hearing loss respectively. The NIHL increased with increasing years of exposure in workplace [14]. It was observed that hearing loss was significantly associated with working experience of more than 10 years [11]. Among weavers, hearing levels decreased with the longer years of work [13]. The development of the hearing loss is characterized by its rapid increase within 3, 4 and 6 kHz during the initial 8 years of exposure, stabilization between years 9-12 and slow moderate increase within the further 13-31 years of exposure [18]. The workers who had been working for more than 20 years were also the most affected (42.9%) [26].

## **Conclusions:**

Workers in weaving section of both factories and preparing section in Alsbagoon factory were exposed to average levels of noise above 85 dBA, the major risk factors for NIHL were the duration and the level of noise exposure and hearing loss was significantly associated with working experience of more than 10 years. This supports the conclusion that decrease noise level at the range of 85–90 dB (A) Leq for 8 h/d (40 h/wk), engineering controlling means should institute to decrease the number of sources of noise production and to reduce the level of noise produced.

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