A cross-sectional study of occupational noise-induced hearing loss among workers in a linearly welded pipe factory: The General Pipe company, Al Gwarsha, Benghazi, Libya.

Ghassan S. Mahmoud, PhD, Mraja Dihoom, DPh, Omar Sudani, MD

Abstract Objectives: To find the prevalence of occupational noise induced hearing loss (ONIHL) among workers of a linearly welded pipe factory, who are exposed to industrial noise. Also, to find the rule of age and duration of exposure on the prevalence.

Design: This study was carried out in 1993 in the linearly welded pipe factory of the General Pipe Company in Benghazi. The linearly welded pipe factory is the largest factory of its kind and employs approximately 416 workers. The workers in the factory are exposed to high levels of industrial noise due to the nature of the work.

Methods: We measured the noise intensity in different parts of the factory which was 96-98 dB for continuous noise, 8 hours per day, 6 days per week. This level far exceeds the recommended dose equivalent in most industrial countries. A list was prepared containing name, age and duration of work in the factory for all the workers. We selected a sample of 71 workers. They were all workers who had been employed in the factory for at least 5 years. Audiogram testing was done for this sample in Al Amal Institute in Benghazi. Each worker enjoyed a day off work prior to the test to avoid threshold shift problems.

Results: Thirty-seven workers (52% of the sample) showed a notch at 4 KHz in their audiogram which is characteristic of the effects of noise on hearing. Fourteen of them (20%) of the sample have average deficit (30 dB at frequencies 1.2 and 3 KHz and are therefore considered cases of ONIHL. The age, duration of exposure of workers affected at 4 KHz (37 workers) and non-affected (34 workers) are significantly different. The age and duration of exposure of workers with ONIHL (n=14), workers affected at 4 KHz (n=23) and non-affected workers (n=34) were significantly different.

Conclusions: There is a need for the protection of workers against exposure to noise by suggesting a dose equivalent, taking into consideration the longer working week, which is 6 days. The noise level, therefore, should be less than 90 dB. Also, there should be a clear definition of ONIHL which should mention the average loss and frequencies included in the calculation of that average in order to be considered as a case of ONIHL.


Keywords: Industrial noise, prevalence, occupational noise induced hearing loss, audiometry.

Noise is one of the features of modern life. It is produced by a wide range of sources. Industry is one of the major sources of noise where it is an important occupational hazard for the working population.

The effects of noise on health are auditory and extra-auditory, acute or chronic. Long term exposure to noise at work may cause occupational noise-induced hearing loss (ONIHL), which is a gradual bilateral, symmetrical, sensorineural (perceptive) and irreversible loss of hearing due to destruction of hair cells in the organ of corti.

Factors that determine the occurrence of ONIHL in addition to exposure to noise are age (presbycusis) and personal susceptibility.

It usually starts as a notch in the audiogram at 4000 Hz. With continuous exposure this notch will deepen and widen to include adjacent frequencies at both sides.

The International Standard (ISO-R 1999:1971) defines a significant loss of hearing as an average loss of 25 dB or more at three frequencies 500, 1000 and 2000 Hz.

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Received February 1995. Accepted for publication final form April, 1996.

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The British Standard (BS 5330, 1976) uses a different definition of impairment which is an average loss of 30 dB at 1000, 2000 and 3000 Hz. Noise control and prevention of exposure have always been difficult and frustrating tasks. Methods include noise control at source, interruption of the path and individual protection. But first, the noise level should be assessed to establish whether it is unjustifiably high.1,2

The dose equivalent level (Leq) for continuous exposure is 90 dB (A) in Belgium, Denmark and France for an 8-hour day, 5 days per week. In Germany it has been reduced to 85 dB(A).1

In certain EEC countries there are criteria for the limitation of exposure to impulse noise. In Belgium the impulse peak sound level exposure is 140 dB. The maximum number of impulses per day is 100.1

So far, no figure is available concerning the prevalence of ONIHL in Libyan Jamahiriya Industry, in spite of the rapid movement of industrialization, which involves exposure of great numbers of workers to the hazards of noise, in the absence of regulations concerning the different aspects of the problem.

In this work, we assessed the noise level and we tried to find the prevalence of ONIHL in the linearly welded factory. The General Pipe Company in Benghazi.

Subjects and Methods The General Pipe Company in Al Gwarsha (Benghazi) is one of the national companies. It provides steel pipes which are used in urban constructions, oil and water wells, natural gas pipe lines and agricultural uses. It is situated in the suburbs of Benghazi. The raw materials are mainly rolled up steel plates brought by sea from Misrata steel factory.

There are 3 main lines of production in this company: the first one is linearly welded pipes which are used primarily for domestic water supply connections. The second line is for the production of spirally welded pipes which are used mainly for industrial purposes, and the third line is for the production of pipes used for agricultural purposes.

Approximately 1400 workers are employed in this company, including administrative staff. The working day is divided into three shifts, 8 hours each, with the morning shift starting at 7 a.m.

The occupational hazards in this industry are many, of which noise is the most important in terms of the number of workers exposed and the serious social disability which may result.

In this work, we studied the ONIHL among workers in the linearly welded pipe factory in which 416 workers are employed. This factory has been chosen because it is the largest in the company and work is continuous throughout the year.

Noise in this factory arises from the production process which is described as follows: In the linearly welded pipe factory, the rolls of steel plates are unrolled and cut according to the required diameter of pipes under manufacture. The cut sheets are then folded and welded linearly to form a pipe.

During this process, which is performed in a single production hall, a great deal of noise is produced by the working machines, which is due to collision between the pipes.

In this production area, noise intensity was determined by the use of a sound level meter (Bruel and Kjaer Denmark type 2232 - portable).

A list was provided by the Company's Administration department, which included for all workers, name, age and length of employment in the factory. Seventy-one workers were included in this study and had spent five years or more in this work.

Evaluation of the degree of hearing loss among this group of workers was carried out by audiogram examination in Al Amal Institute for the Deaf and Dumb in Benghazi. Each worker had enjoyed one day's holiday prior to the audiogram examination in order to avoid threshold shift problems.

The audiogram was carried out using the same instrument and technician for all workers, to avoid problems of intra and interobserver variations.

The audiogram was carried out using an audiometer type OB 822 clinical audiometer manufactured by Swedvelop Hospital AB (1984) provided with isolated cabin.

The given signals were (0 to 120 dB at each frequency from 125 Hz to 8 KHz). Both air and bone measurements were carried out for all workers.

The mean reading between left and right ears was considered to be the final reading of each subject. Left and right readings were considered symmetrical when the difference between them was not more than 20 dB.

Occupational noise induced hearing loss starts at 4 KHz. The degree of hearing loss was taken as the average of hearing loss at the frequencies 1, 2, 3 KHz.

Results Environmental measurement of noise, Noise level was assessed using a sound level meter. Assessment was made in all the linearly welded pipes and galvanization workplaces. At
each workplace, the instrument was placed at a height of 1.5 meters in a horizontal position towards the source of noise.

Two different types of noise were detected, continuous and impulse noise.

The continuous noise level was on average between 96-98 dB throughout the linearly welded pipe factory and place of galvanization.

Impulse noise resulting from the fall of pipes upon each other in the linearly welded pipe factory was about 110 dB at a rate of 6 times per minute.

In the galvanization workplace, an impulse noise generated by a jet of air, used to clean the walls of the pipes from the remnants of zinc, was about 106-112 dB at a rate of at least 3 per minute.

**Prevalence of audiograms with a notch at 4 KHz (≥25 dB).** A notch at 4 KHz, showing a deficit of 25 dB and more, was considered as a sign of the effects of noise on hearing.

Among the 71 workers examined in this study, 37 (52%) were showing a notch at 4 KHz (≥25 dB). When they are distributed over 3 age categories (<30, 30-39.9 and >40 years), the prevalence of affected workers in each category was 15.8%, 58.5% and 91% correspondingly (Table 1).

**Table 1:** Age distribution of affected and non-affected workers according to audiogram changes of a deficit of ≥25 dB at 4 KHz and the prevalence of workers with deficit in each category.

<table>
<thead>
<tr>
<th>Age in years</th>
<th>Affected</th>
<th>Non-affected</th>
<th>Total</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;30</td>
<td>3</td>
<td>16</td>
<td>19</td>
<td>15.8%</td>
</tr>
<tr>
<td>30-39.9</td>
<td>24</td>
<td>17</td>
<td>41</td>
<td>58.5%</td>
</tr>
<tr>
<td>&gt;40</td>
<td>10</td>
<td>1</td>
<td>11</td>
<td>91%</td>
</tr>
<tr>
<td>Total</td>
<td>37</td>
<td>34</td>
<td>71</td>
<td></td>
</tr>
</tbody>
</table>

The mean age of non-affected workers was 31 years and the standard error of the mean was 0.877 (the mean ± 2SE = 29.246 - 32.754).

The mean age of affected workers was 37.16 years and the standard error of the mean was 1.198 (the mean ± 2SE = 34.764 - 39.556).

The difference between the two means of age was significant p<0.001 (Table 3).

The range of duration of exposure of workers in this sample was 5-20 years. When they were distributed over 3 categories (5-9.9, 10-14.9 and 15-20 years), the prevalence of affected workers in each category was (27%, 62.5% and 71.4%) correspondingly. The difference in prevalence between the 3 categories was significant, X² = 10.8, p<0.05 (Table 2).

The mean duration of exposure of non-affected groups was 10.382 years, the standard error of the mean is 0.747 (the mean ± 2SE = 8.887-11.877).

Mean duration of exposure of the affected group was 13.486 years, the standard error was 0.597 (mean ± 2SE = 12.192-14.58).

The difference between the two means of duration of exposure was significant p<0.005 (Table 3).

**Prevalence of ONIHL.** According to the British Standard Definition of ONIHL, 14 workers have a

<table>
<thead>
<tr>
<th>Duration of exposure in years</th>
<th>Workers affected at 4 KHz</th>
<th>Non-affected workers</th>
<th>Total</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-9.9</td>
<td>7</td>
<td>19</td>
<td>26</td>
<td>27%</td>
</tr>
<tr>
<td>10-14.9</td>
<td>15</td>
<td>9</td>
<td>24</td>
<td>62.5%</td>
</tr>
<tr>
<td>15-20</td>
<td>15</td>
<td>6</td>
<td>21</td>
<td>71.4%</td>
</tr>
<tr>
<td>Total</td>
<td>37</td>
<td>34</td>
<td>71</td>
<td></td>
</tr>
</tbody>
</table>

**Table 3:** Statistical comparisons between the means of age and duration of exposure of the affected and the non-affected worker.

<table>
<thead>
<tr>
<th>Years</th>
<th>non-affected n = 34</th>
<th>affected n = 37</th>
<th>t = student’s test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>SEM</td>
<td>mean</td>
</tr>
<tr>
<td>Age</td>
<td>31</td>
<td>0.877</td>
<td>37.16</td>
</tr>
<tr>
<td>Duration of exposure</td>
<td>10.382</td>
<td>0.747</td>
<td>13.486</td>
</tr>
</tbody>
</table>
hearing deficit >30 dB at frequencies 1,2,3 KHz, therefore the prevalence of ONIHL is 20% among workers exposed for >5 years to industrial noise in this company.

Differences of age and duration of exposure of this group (14 workers) and the remainder of those affected at 4 KHz (23 workers) and non-affected workers (34) was significant (Table 4, Fig. 1).

<table>
<thead>
<tr>
<th>Source</th>
<th>D.F.</th>
<th>Mean Square</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>2</td>
<td>431.5</td>
<td>10.89</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Within groups</td>
<td>68</td>
<td>39.61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of exposure</td>
<td>2</td>
<td>89.876</td>
<td>5.355</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Within groups</td>
<td>68</td>
<td>16.781</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Dose equivalent in most Arab countries should be even less than 90 dB for an 8-hour day, 6 days per week, as the working hours per week are 48 compared to 40 in Europe.

Indeed, the noise level in this industry far exceeds the accepted level of exposure by most industrial countries. The audiological assessment of cases with hearing loss using air and bone conduction audiometry is a standard and often key element in the diagnostic process. This is especially true in the diagnosis of noise induced hearing loss where a main audiometric feature of interest is typically a sensorineural “notch” at 4 KHz.

Lightfoot GR and Huges JB (1993) have recommended that bone conduction tests by audiometry at frequencies greater than 4 KHz should be avoided, due to the air radiated sound from the bone vibrator in the frequencies 3-8 KHz.

In the present study, our calculations were based on air conduction audiometry. Bone conduction audiometry was carried out simultaneously and was used for the confirmation of the diagnosis.

Results have clearly pointed out age and duration of exposure as risk factors. Actually each one of these parameters may reflect the other, as older workers have longer durations of exposure. Exceptions to this rule were due to individual susceptibility or resistance.

In the present situation, health education of workers regarding the ill health effects of noise and provision of individual protective equipment seem to be the most feasible methods for the protection of workers against further exposure to industrial noise. They should be educated in the proper use of protective equipment. Those workers who follow the safety instructions should be encouraged and rewarded.

Workers having ONIHL (14 workers, 20% of the sample), should be considered for professional reorientation or removed from key posts during the workshift. Every effort should be made to protect from further exposure those who are affected at 4 KHz (23 workers, 32% of the sample), as they are potential candidates for ONIHL.

Periodic examination should include audiometry for all exposed workers at least once per year. The newly employed should be examined after the first 6 months of their employment to exclude susceptible individuals.

**Discussion**

The purpose of this study was to focus both management and health workers attention towards hearing impairment resulting from exposure to industrial noise.

The hearing handicap interferes with employees productivity and increases their proneness to accidents by reducing their ability to communicate with others.

The workers in this industry are exposed to daily noise without hearing protection of any kind.

Dose equivalent Leq dB (A) of noise in many western industrial countries is set at 90 dB for an 8-hour day, 5 days per week, which is not completely protective.

**Conclusion**

There should be an official definition of ONIHL pointing out the criteria of
diagnosis and the medico legal aspects. Adopting the International Standard (ISO-R 1999: 1971) definition seems more favorable, from the workers point of view, as it considers a lower margin of average loss i.e. 25 dB at frequencies 500, 1000 and 2000 Hz, while the British Standard (BS 5330, 1976) uses an average loss of 30 dB at frequencies 1000, 2000 and 3000 Hz. The superiority of the British Standard is that it includes the frequency 3000 Hz which can reflect earlier deficit in the auditory capacity as it is closer to the notch at 4 KHz. In fact, these criteria are based on international and local experience and on the sociopolitical system of each country.

Acknowledgment The cooperation of the Al Amal Institute for the Deaf and Dumb in Benghazi is gratefully acknowledged. Acknowledgments are also extended to the administration of the General Pipe Company in Benghazi for their continuous support.

References

2. World Health Organization (WHO); Environmental health criteria 12: noise 1980.
دراسة مقطوعية لفقدان السبيع الناجح عن التعرض للضوضاء الصناعية بين العاملين
في مصنع الأنابيب الملحومة طوليا التابع للشركة العامة للأنابيب، بنغازي - ليبيا

د. غسان شاكر محبود، د. الإقراض دهيمو، د. عمر السوداني

هدف الدراسة: تهدف الدراسة إلى معرفة نسبة إصابة العاملين في مصنع الأنابيب الملحومة طوليا بمرض فقدان السبيع الناجح عن التعرض للضوضاء الصناعية، وكذلك معرفة نسبة الإصابة في المجامع العمرية المختلفة وتبها لبنة

الอาศاف في هذا المصنع.

خططة الدراسة: أجريت هذه الدراسة خلال عام 1993 م الموافق 1414 ه في مصنع الأنابيب الملحومة طوليا التابع للشركة العامة للأنابيب في بنغازي. يعتبر هذا المصنع أكبر مصنع للأنابيب في بنغازي، ويشتغل فيه أكثر عدد من العمال الذين

ي تعرضون لمستويات عالية من الضوضاء الصناعية الناجة عن طبيعة العمل.

طريقة إجراء البحث: تم قياس مستويات الضوضاء في مختلف أرجاء المصنع، حيث تبين أنها تتراوح ما بين 98-96 dB بالنسبة للضوضاء المتواصلة على مدى 8 ساعات عمل في اليوم الواحد، لمدة 6 أيام في الأسبوع.

وهي مستويات تتجاوز مكافئ الجرعة المعتمد في أغلب الدول الصناعية.

تم إعداد قائمة بأسماء جميع العاملين وأعمارهم ومimetype استثالهم في هذا المصنع. اختيرت عينة من 72 عامل وهم جميع العمال الذين مضي على استثالهم في هذا المصنع 5 سنوات فاتك. ثم أخذت هذه العينة لاختبار تخطيط السبيع في معهد الأم للفحص والتربة في بنغازي وذلك مباشرة بعد تمتعهم بيوم استراحة واحد.

نتائج البحث: تبين من خلال البحث أن عدد العمال المصابين بفقدان في السبيع C25 على تردد 250 في الثانية كان 37 (22% من العينة)، من بينهم 24 عاملاً (20% من العينة) كان معدل فقدهم السبيع لديهم على التردد 1000، 2000 و 3000 ديزيبل ذPKO في الثانية هو 30 دب فأكثر.

كان عامل التعرض ودومة الاشتغال في هذه الصناعة يختلفون اختلافاً إحصائياً ذو دالة معنوية بين المصابين على التردد 2000 ديزيبل في الثانية وعدهم 37 (24%) وغير المصابين وعدهم 34 (22%). كما أن عامل التعرض ودومة الاشتغال في هذه الصناعة كان يختلفون اختلافاً ذو دالة معنوية بين المصابين على التردد 4000 ديزيبل في الثانية فقط وعدهم 33 (24%) والصابين على التردد 1000، 2000 و 3000 ديزيبل في الثانية وعدهم 20 (20%) وغير المصابين وعدهم 24 (24%).

الخلاصة: تبين من خلال البحث أن هناك حاجة ماسة لحماية العمال من الضوضاء الصناعية من خلال

اعتماد مكافئ جرعة باخذ بنظر الاعتبار طول مدة أسبوع العمل الذي يبلغ 4 أيام. وبالتالي يجب أن يكون مكافئ الجرعة أقل من 90 dB. كذلك يجب أن يكون تعريف الإصابة بمرض فقدان السبيع الناجح عن التعرض للضوضاء الصناعية واضحاً من خلال تحديد معدل فقدان السبيع والدبيبات الداخلة في التعرض.

771 Saudi Medical Journal 1996; Vol. 17 (6)