Original article

Noise-induced hearing loss among textile workers

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Abstract: A cross-sectional study was conducted in Dire-Dawa Textile Factory in October-December 1994, to assess the prevalence of, and risk factors for, noise-induced hearing loss (NIHL). A sample of 630 workers was selected from the factory rosters by means of systematic sampling technique. Data were collected through interview, otologic examination, and pure tone audiogram measurement. Environmental noise survey and personal dosemeter data were also collected to determine noise exposure levels at every section of the mill. The highest noise level in area samples was observed in the weaving section, with mean ± SD of 99.5±3.2 dB. Audiometric tests, measured at a frequency of 4,000 Hz, revealed a 34% overall prevalence of NIHL, (hearing threshold level exceeding 25 dB), with the highest prevalence of 71.1% observed among the weavers. Preventive interventions were generally absent, with no employee reporting use of personal protective devices (PPDs). In view of the documented risk of NIHL among these workers, implementation of a hearing conservation programme is recommended. [*Ethiop. J. Health Dev.* 1999;13(2):69-75]

Introduction

A healthy and productive worker is critical to sustainable social and economic development. With industrial development, occupational diseases have been recognized as a growing problem in developing countries over the recent past decades. However, efforts to address occupational health problems received very little attention by health service planners due to the lack of statistics. In addition, occupational health diseases often have a long latency period and are difficult to diagnose(14).

The discipline of occupational medicine has historically been poorly developed and its research is generally overlooked. Modernization of industry and agriculture often creates occupational hazards, such as through increased mechanization and broader use of industrial toxins like radioactive isotopes and pesticides. Yet, because they are socio-economically disadvantaged, workers in developing countries have rarely demanded increased investment in safety precautions in the workplace(1,5).

Noise is a major health threat in occupations where the level exceeds the normal value. Any sound may be perceived as "noise", pollution when it causes discomfort or adverse health effect. The damaging effects of noise include hearing impairment (loss), and adverse influence on other bodily functions, such as elevation of blood pressure and interference with communication by speech. Textile factories are among the many occupational settings that pose the risk of noise-induced hearing loss(NIHL)(5-8).

Although dangerous noise levels have been previously measured in Ethiopian factories (9,10), no study has documented specifically about noise-induced hearing loss. Thus, this study was designed to determine the prevalence of noise-induced hearing loss among industrial textile factory workers.

Methods

A cross-sectional study to determine the prevalence of noiseinduced hearing loss was conducted in a textile factory in DireDawa between October 1 and December 30, 1994. The factory was established by the Italians in 1931. About 5900 workers are employed in the factory.

A sample size of 505 was calculated to permit determination of a single proportion with 90% power, 95% confidence level, and a margin of error of $\pm$4, assuming that a 30% prevalence of hearing loss would be detected. The sample was raised by 30% to 655, anticipating a large number of individuals would meet the exclusion criteria. The study population was selected from the factory roster using systematic sampling method.

Workers included in the sample were subsequently excluded if they: 1) previously had worked in another noisy occupation; 2) shifted jobs within the textile factory; 3) reported a history of ruptured tympanic membrane or other auditory deficit; or 4) had otoscopic evidence of current tympanic membrane rupture. These exclusion criteria are similar to those used in other studies(11). Data were collected through interviews, physical examination, audiometry and environmental noise survey. A standard questionnaire used for measuring occupational hearing capacity (8)was modified for use in the interview. The questionnaire was modified in order to obtain a complete history relevant to hearing, including demographic data, duration of occupational exposure, history of auditory problems, and use of personal protective device (PPD). Interviews were conducted by locally recruited and trained interviewers. Otoscopic examinations were done by a physician to detect any evidence of current tympanic membrane rupture.

Pure tone audiometric records were obtained by a trained audiometric technician using a manual recording audiometer (Model MA 19, manufactured by Maico Hearing Instruments Inc., Minneapolis, Minnesota, USA), which is commonly used in industrial audiometry. The audiometer was calibrated at the outset of the study and recelebrated regularly using biological standards. Biological standards are healthy individuals on which the instrument is calibrated under the same environmental conditions. The procedures for biological calibration and audiometric techniques were adapted from those used by the provincial Workman's Compensation Board of British Columbia(8). The threshold level was defined as the lowest level at which the subject responded to the tone, at least twice, with five decibel (dB) step increments(5,6,11).

All audiometric tests were carried out in a quiet room outside the factory before the workers entered their work shift to avoid the effects of temporary threshold shifts, due to recent noise exposure inside the factory. Subjects were considered impaired when their hearing threshold level exceeded 25 dB(12). The background noise level in the examination room was usually 45 dB(A) (the A-weighted level is commonly used to define degrees of auditory risk), and was checked twice per day to ascertain that it remained below 50 dB(A), the accepted standard in many industrialized countries, including United Kingdom(12). The testing frequency was at 4000Hz since the deficits due to nose-induced hearing loss are confined to this frequency(7). The American College of Occupational and Environmental Medicine Noise and Hearing Conservation Committee defines occupational noise-induced hearing loss as a "slowly developing hearing loss over a long period as a result of exposure to continuous or intermittent loud noise. The diagnosis of noise-induced hearing loss is made clinically by a physician and should include a study of the noise exposure history." (13). Environmental noise surveys were carried out by trained technicians in every work station using a precision sound level meter (model B & K type 2232, made in USA). In each section (administration, preparation, spinning, and weaving), approximately 20 locations (work stations) were selected. Three measurements were taken on three separate days to obtain an average noise level for each work station. A personal dose meter (model B & K type 4428, made in USA) was used to establish a total noise dose over eight hours of exposure on randomly selected workers from all sections.

The person involved in audiometric evaluation had relevant training and experience in activities of the same nature. The

physician involved in the otoscopic examination had also five years experience in routine otoscopic examination, in addition to which a short attachment was arranged with a specialist.

Informed consent was obtained from each participant. Appropriate treatment was provided for those participants in whom an ear problem was detected; those who needed further medical care were referred. Necessary arrangements were made with the factory management to provide counseling for those affected with NIHL.

Data entry and analysis were performed using Epi Info version 6(14) and SAS(15) statistical software. Data were analysed to determine the overall prevalence of hearing loss and to provide specific prevalence rates in various sections of the factory. To determine association between hearing loss and the selected factors, odds ratio (OR) was calculated with 95% confidence interval (95% CI). Adjustment for confounding effects was achieved using the logistic regression model.

Results

Interview and Physical Examination: Of the 655 workers who were selected for the study, 630 satisfied the study requirements and were included in the study. A total of 25 workers were excluded from the study. Excluded were: four employees who had previously worked in another noisy occupation, twelve who had shifted jobs within the textile factory, two who reported a history of ruptured tympanic membrane, and seven who had otoscopic evidence of current tympanic membrane rupture.

The mean age of the participants was 34.3 years, with a range from 20 to 59 years. There was no significant difference in the distribution by age and sex for workers in the four sections of the factory (weaving, spinning, preparation, and administration). Overall, 46.3% of the study participants are females. The mean± SD educational attainment was grade 8±3. The mean±SD monthly income for the study participants was 240±95 Ethiopian Birr (then 1 USD= 5 Birr). Most (73.8%) were married and living in union. The mean duration of employment within the same job was 15.7 years, with a range of 1-39 years. There was no significant difference in the duration of employment by the section of the factory.

History of hearing loss was reported by 51(8.1%) participants, while 57(9.0%) reported a history of ear disease. More than asame third (34.3%) complained of current ear problems, and 186 (29.5%) complained of ear pain (Table 1). None of the participants reported the use of Personal Protective Device

(PPD) for reasons such as lack of availability (71.6%), lack of knowledge of PPDs (18.6%), and belief that PPDs are ineffective (9.8%).

On physical examination, 154 (24.4%) were found to have detectable ear problems, of whom 66 (42.9%) had otitis, while the remainder had cerumenous occlusion of the auditory canal. There was no significant difference by gender in the prevalence of detectable ear problems. Only 21 participants had both a history of "ear disease" and current detectable ear problems on physical examination.

Audiometric Examination: The overall prevalence of NIHL in either ear was 214 out of 630(34.0%) workers when measured at a frequency of 4000 Hz. Using administration workers as the reference group and after adjusting for age, the prevalence of NIHL was significantly higher for both spinners and weavers, but no difference was seen among reparation workers (Table 2). The association observed between NIHL and age was significant, but when adjusted for the duration and intensity of noise exposure, the association disappeared (Table 3).

Of the 214 subjects with NIHL, 63(29.4%) had either otitis or cerumenous occlusion of the external auditory canal. There was significantly higher NIHL among workers withotitis or cerumenous occlusion of the external auditory canal on the crude analysis (OR=1.49, 95%CI=1.02,2.17) but the association was not stable after adjusting for age and year of service (OR=1.17, 95%CI=0.72, 1.90). The prevalence of NIHL between those with otitis and those with cerumenous occlusion was not significantly different. The prevalence of NIHL increased with increasing years of exposure in the workplace (Chi-square for linear trend = 45.9, $p< 0.001$) (Table 4).

Environmental Noise Survey: None of the 10 buildings within the Textile Factory complex had any acoustical materials appliedto interior surfaces. Neither the buildings nor the machinery used in the factory had any evidence of having been designed and constructed to reduce noise levels in work stations.

Workers are exposed continuously to noise(exposure levels are shown in Table 5) for an entire eight-hour shift except during a single half-hour meal break. The factory is in use for 24 hours, five days per week. NIHL also showed an increase with increasing levels of noise exposure (Chi-square for linear trend based on the crude data= 174.1, $p< 0.001$ (Table 6).

Discussion

This study demonstrated that noise is a serious occupational health hazard in the textile factory which was studied. 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 in Thailand and Egypt(16,17). The higher noise levels in the weaving and spinning sections, reflected in higher prevalence of NIHL among workers in those sections, have also been documented by previous studies in other countries (16-18). Though the exclusion criteria are the same with other studies and allow comparability of findings, they have the potential to cause underestimation of the NIHL level. The "healthy worker effect" could also be suspected of causing underestimation of the NIHL level since there is no well-organized health services for occupational health problems in the factory. This means that workers suffering from severe hearing loss might have left the factory, leaving relatively healthy workers in the factory. In which case, the NIHL estimate from a cross-sectional survey would underestimate the true magnitude of the problem. This suggests that the actual NIHL level could be higher than what was observed in this study.

Weavers and spinners in the factory were exposed to average levels of noise above 85 dB(A), the threshold limit value set by many industrial countries in Europe and United States(11), as well as in some African countries, including Zimbabwe(19) and Kenya(20). The noise level of nearly 100 dB(A) in the weaving section is comparable to the 99.5 dB(A) level measured in weaving sections of textile mills in Asmara (9), 102.5 dB(A) in Hong Kong(18), 101.3 dB(A) in Thailand (17), 100 dB(A) in Egypt (16,21), and 99-102 dB(A) in a jute weaving mill in the UK(22).

In the Dire Dawa mill, these high noise levels are likely due, in part, to poor safety engineering of its outdated machinery. Additional noise-enhancing factors noted during the environmental survey included poor design and construction, and crowding of work space. In addition to increasing the risk of NIHL, such working conditions put workers at increased risk of other occupational injury due to their hampered ability to perceive warning signals.

The study detected an increasing auditory deficit with increasing age. This finding may reflect the well-known phenomena of presbycusis, the "normal" deterioration of hearing with age, and/or sociocusis, the "normal" deterioration of hearing loss due to noise generated from the "normal" living environment such as from music, car, and train noise(11,18). However, when the

duration and the intensity of noise exposure were adjusted for, the trend observed between increasing auditory deficit and age disappeared. This may imply that observed auditory deficit is more likely to be due to noise exposure rather than to age.

Though it is difficult to generalize the findings of this study done in only one factory which may be uniquely different from other textile factories in the country, the study clearly demonstrated that noise is a serious health hazard in Dire Dawa Textile Factory.

Based on the study findings, implementation of hearing conservation programme through development and enforcement of regulations to identify and monitor occupational risk groups, and restriction of importation of equipment which emits dangerous levels of noise are recommended. In addition, engineering modifications of buildings and machinery to reduce noise levels, and promotion of safety and health programmes, including promotion of workers' awareness on self-protective measures, such as the use of personal protective device(PPD), should be considered. In Ethiopia, there is no specific legislative framework to protect workers against industrial hazards.

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Table 1. **Noise-induced Hearing loss related to selected factors among Dire -Dawa Textile Factory Workers, Dire Dawa, Ethiopia, 1994. 1994.(n=630)**

	No-NIHL(n=416)	OR(95%CI)
	34	0.97(0.51,1.85)
	385	

3
7
(1.06(0.57,1.93)
3
7
9

1
4
5 0.93(0.64,1.33)

2
7
1

1
2
2 1.03(0.71,1.50)

2
9
4

1
0
7 1.23(0.84,1.81)

3
0
9

2
2

5 1 9 1	1.05(0.75,149)

Table 2: **Noise- induced Hearing loss by work sections in Dire Dawa Textile Factory, Dire Dawa, Ethiopia, 1994.**

(NIHL cases= 214 and Non -NHL=416)

Section(N)	Cases of Hearing Loss(%)
Administration(167)	13(7.8)
Preparation(72)	13(18.1)
Spinning(253)	89(35.2)
Weaving(138)	99(71.7)
Total (630)	214(34.0)

*Adjusted for age

Table3: **Noise-induced Hearing loss by age among Dire Dawa Textile Factory Workers, Dire Dawa, Ethiopia, 1994. (NIHL cases= 214 and Non-NIHL= 416**

Age	Ca in	ses Yea	of r	He			(N)	ari ng Lo ss(%)
	<30 (19 5)							50(25. 6)
)			30	87(274	39(8)	31.		
	40-49(133)							63(47. 4)
	>50 (28)							14(50. 0)
Tot al(6 30)								21 4(3 4.0)

*Adjusted for duration and intensity of noise exposure.
** Chi-square for liner trend based on cruddata=18.74, Pvakye=0.001

Table 4: **Noise- induced Hearing loss by years of exposure in Dire Dawa Textile Factory, Dire Dawa, Ethiopia, 1994.(NIHL cases=214 and Non- NIHL=416)**

Exposure in Years(N)	Cases of Hearing Loss(%)
<10(138)	24(17.4)
1019(308)	93(30.2)
>20(184)	97(52.7)
Total(630)	214(34.0)

* Adjusted for age and sex. **Chi=square for trend based on the cruddata=45.99;Pvalue=0.001

Table 5:**Noise levels by work area in Dire Dawa Textile Factory, Dire Dawa, Ethiopia, 1994.(n=630)**

Section(N)	Samples
Administration(1)	16
Preparation (2)	47
Spinning(5)	107
Weaving	49
Total	219

dB Unit of measurement of sound level or intensity dB(A) Equivalent continuous sound level in the course of an eight working day.

Table 6: **Hearing loss by level of noise exposure in Dirdawa Textile Factory, Dire Dawa, Ethiopia, 1994.**

Exposure level	Workers exposed