Prevalence of noise-induced hearing loss in metallurgical company

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Hearing loss, noise-induced, epidemiology. Workers. Occupational exposure. Noise, occupational. Occupational health. Cross-sectional studies. Prevalence.

Abstract

Objective
To analyze the prevalence of cases suggestive of noise-induced hearing loss (NIHL) among metalworkers who were potentially exposed to occupational noise (from 83 to 102 dB).
Methods
A cross-sectional study was carried out in a metalworking company providing services in Rio de Janeiro, Brazil. Clinical and occupational data on 182 workers who were active between November 2001 and March 2002 were obtained from the company's Hearing Conservation Program and analyzed. In order to characterize the noise exposure status within the work environment, the acoustic classifications from the operating units of the client companies were used, due to difficulty in quantification at an individual level. Associations between these cases and variables such as age, length of service in the company, length of exposure to occupational noise and degree of use of individual protection equipment were tested by means of prevalence ratios and logistic regression analysis.
Results
The prevalence of cases suggestive of NIHL was 15.9% and significant associations ($p<0.05$) were identified from multivariate analysis between these cases and the variables of age and degree of use of individual protection equipment.
Conclusions
The results found contribute towards better understanding of the behavior of some of the main characteristics of NIHL, in a particular situation of the organizing of work that is relatively common in the Brazilian industrial context.

INTRODUCTION

Work-related hearing loss, and particularly noise-induced hearing loss (NIHL), is a highly prevalent occupational illness in industrialized countries, and it is prominent as one of the most prevalent health hazards for workers in Brazilian industry.[4] It is characterized by gradual reduction in auditory acuity, generally over a period of six to ten years of exposure to high levels of sound pressure.[11] It is always neurosensory in nature and irreversible, starting with the loss of high audiometric frequencies.*

Even though the existence of noise in the working environment is considered to be one of the main risk factors in the genesis of occupational hearing loss, other agents of diverse nature may cause hearing deficits, through interaction with noise, thereby increasing the effect of noise on hearing.[3] A variety of factors are often related to the occurrence of hearing losses, such as age, cranial trauma, exposure to noise outside of the workplace, smoking, systemic diseases, family history of hearing deficits and exposure to chemical agents in the workplace.[1,2,6,11,13]

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The diagnosis of NIHL of occupational origin depends on the typical representation seen on audiograms and the proving of the existence of exposure to noise within the working environment, while always considering the intensity and characteristics of the agent, as well as the type of exposure.*

In most cases, NIHL does not cause incapacity for work.* This leads to notification difficulties regarding this hazard to workers' health in Brazil. Thus, the estimates of the prevalence of this illness among the different categories of workers in Brazil are basically made by means of epidemiological studies.[1,7,9,10,12,14,15]

Although NIHL has practically reached endemic proportions within the industrial environment, scientific studies on its natural history among Brazilian workers are still scarce.[4] The great imprecision in quantifying the level of individual exposure to noise observed in Brazilian industry should also be noted. Sustained scientific exploration of the behavior of NIHL among these workers therefore becomes necessary.

The present study had the objective of analyzing the prevalence of hearing loss that was suggestive of NIHL among the workers at a metalworking company, whose exposure to occupational noise at the individual level was difficult to characterize.

METHODS

This was a study with cross-section delineation, carried out from November 2001 to March 2002, in a private metalworking company that provides technical services of preventive and corrective mechanical maintenance for medium to large-sized refrigeration equipment, located in the city of Rio de Janeiro, Brazil. Metalworkers who provided services within client companies that were included within the scope of the Hearing Conservation Program during the period of the research were analyzed. Thus, 194 workers filled out questionnaires, of whom 12 (6.2%) were excluded because there were no audiometric results for these workers. The study was therefore conducted on 182 workers, who represented around 74% of the total number of workers who were providing services within these companies.

Because of the difficulty found within the Hearing Conservation Program for quantifying the individual level of exposure to noise at each work post, only the acoustic classifications of the operating units of the client companies were utilized for characterizing the status of noise exposure within the working environment. Thus, all the workers studied were classified as potentially exposed to occupational noise, since they performed their activities in production sectors with sound pressure levels above the legal tolerance limit for eight hours per day (>85 dB),* according to the assessment for the Environmental Risk Prevention Program that was carried out in the company in 2001. These sound pressure levels varied not only from sector to sector, but also within sectors, ranging from 83 to 102 dB, according to the activity performed: scheduled preventive maintenance and/or unscheduled corrective maintenance (measurements made using the Minipa MSL 1350 digital decibel meter with internal calibrator).

A self-administered questionnaire drawn up through the company's own Hearing Conservation Program was utilized. This was based on present knowledge of the natural history of NIHL, so that a data collection instrument could be constructed that would enable investigation of the main factors associated with this illness. In accordance with the priorities of the preventive program, which was destined solely for the population exposed to occupational noise, the questionnaire was initially applied to the workers dispersed around the various client companies. This stage of the data collection was performed as an integral part of the Hearing Conservation Program, and was conducted together with talks on auditory healthcare for the workers, with clarifications about NIHL, the issuing of Work Accident Communications (CAT) when necessary, and the distribution of individual protection equipment.

A databank was set up, containing all the information available from the questionnaire and also from the records of the company's specialized service for safety engineering and occupational medicine (SESMT). These records consisted of audiometry results, other clinical data and administrative information. All the audiometric examinations were performed by service providers of recognized technical quality, in accordance with the norms recommended in Brazil.*

The variables analyzed were the following:

Dependent variable (outcome)

The dependent variable was hearing loss suggestive of NIHL, which was characterized from evidence of neurosensory hearing deficit suggestive of NIHL in the audiometric examinations, according to the criteria established by Ordinance no. 19 of the Ministry of Labor and Employment (1998).[8]

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Independent variables (exposure)

The independent variables were age, length of service in the company, total length of exposure to occupational noise (estimated from the workers' reported individual perception of exposure to the physical agents over the course of their whole working lives), degree of use of individual protection equipment (characterized by reports of utilization of ear defenders by workers whenever they were performing activities in noisy environments), exposure to noise outside of the workplace (habit of using firearms, going to noisy parties, or letting off fireworks or mortars), occupational exposure to chemical products (solvents, reducing agents, oils and greases), family history of hearing deficits, present and/or previous history of smoking, personal history of hypertension and diabetes mellitus, and previous history of cranial trauma. The distribution of frequent complaints of buzzing sounds and hearing difficulties in noisy environments among the study population were also analyzed.

The data analysis observed the following steps:

- Univariate analysis with a description of the distribution of the dependent and independent variables in the study population;
- Bivariate analysis, done by crossing the dichotomous dependent variable with each of the independent variables, in accordance with their nature, by means of contingency tables (chi-squared test and, when necessary, the Fisher exact test). In the 2x2 tables, prevalence ratios (PR) and odds ratios (OR) were calculated, with their respective 95% confidence intervals 95% (95% CI). To test differences between means, the Student t test was utilized;
- Multivariate analysis for controlling for confounding factors, by means of multiple logistic regression using the manual backward-forward stepwise strategy.[5] For the multivariate analysis, the most significant variables ($p \leq 0.2$) from the bivariate analysis and/or most relevant variables in the context of NIHL were selected. The criteria for variables to be kept in the final model also took into account the significance level and the relevance of these variables, in addition to the quality of model adjustment. The presence of interaction between age and length of exposure to occupational noise was also investigated.

The values of the likelihood ratio and the Hosmer-Lemeshow test, respectively, were utilized to assess significance and the quality of model adjustment, at all stages. The statistical software utilized was Epi Info (version 6.04b), for data entry and analysis, and SPSS 8.0 for Windows, for the multivariate analyses.

The present research was approved by the research ethics committee of the University Hospital of the Federal University of Juiz de Fora (CEP/HU-UFJF).

RESULTS

The study population was made up solely of male workers, with ages ranging from 19 to 70 years (median: 35.5; 25th percentile: 25.0; 75th percentile: 46.0), and 61.5% aged no more than 40 years. The mean length of service in the company was 7.6 years (median: 5.0; 25th percentile: 2.0; 75th percentile: 12.1). The mean length of exposure to noise in the working environment was 9.9 years (median: 6.0; 25th percentile: 2.0; 75th percentile: 16.0). The prevalence of cases suggestive of NIHL was 15.9%, with a confidence interval of 10.9% to 22.1%.

In the bivariate analysis, the distribution of cases suggestive of NIHL presented significantly increasing prevalence ($p<0.05$) that was directly proportional to increasing age, length of service in the company and length of exposure to occupational noise. The PR for length of exposure to occupational noise greater than or equal to 20 years was 4.65 (95% CI: 2.01-10.72). The prevalence of cases suggestive of NIHL was lower among the workers who reported that they regularly used individual protection equipment ($p=0.09$) and higher among those who reported occupational exposure to chemical products ($p=0.3$), in relation to the workers who did not report these facts (Table 1).

The workers with audiometry results suggestive of NIHL presented mean age, mean length of service in the company and mean length of exposure to occupational noise of 50.2 years, 14.1 years and 16.6 years, respectively. These figures were greater than those observed for the other workers ($p<0.05$) (Table 2).

Greater prevalences of cases suggestive of NIHL were identified among workers with histories of exposure to noise sources outside of the workplace (25.0%), cranial trauma (24.2%), arterial hypertension (22.7%) and diabetes mellitus (30.0%), in comparison with workers without such histories (15.7%, 13.8%, 15.5% and 15.6%, respectively). These differences were not significant ($p<0.05$). The prevalence of cases suggestive of NIHL was lower among workers with a family history of hearing deficit (PR: 0.18; 95% CI: 0.02-1.25) and higher among those with a present and/or previous history of smoking (PR: 3.46; 95% CI: 1.78-6.73), in relation to workers without reports of such histories. With regard to clinical symptoms related to hearing, cases suggestive of NIHL were brought into evidence for 33.3% and 62.5% of the workers with frequent complaints of buzzing

Table 1 - Percentage distribution of the population studied (%), prevalence of cases suggestive of NIHL and prevalence ratio, according to age group and occupational data.

Variables	%	Prevalence	PR (95% IC)*	p-value
Age group				
Up to 29	39.0	4.2%	1.00	
30 to 39 years	20.3	5.4%	1.28 (0.22-7.32)	1.00**
40 to 49 years	23.6	20.9%	4.95 (1.42-17.30)	<0.01**
50 and over	17.0	48.4%	11.45 (3.57-36.73)	<0.01**
Length of service in the company				
0 to 5 years	55.5	5.9%	1.00	
6 to 10 years	14.8	22.2%	3.74 (1.31-10.68)	<0.01
11 to 20 years	20.3	27.0%	4.55 (1.78-11.64)	<0.01
20 years and over	9.3	41.2%	6.93 (2.65-18.14)	<0.01
Length of exposure to occupational noise				
0 to 5 years	48.6	8.3%	1.00	
6 to 10 years	16.2	14.3%	1.71 (0.54-5.42)	0.46**
11 to 20 years	17.3	20.0%	2.40 (0.88-6.57)	0.08
20 years and over	17.9	38.7%	4.65 (2.01-10.72)	<0.01
Degree of use of individual protection equipment				
Not used regularly	44.2	21.3%	1.00	
Used regularly	55.8	11.9%	0.56 (0.28-1.10)	0.09
Occupational exposure to chemical products				
No	53.6	13.4%	1.00	
Yes	46.4	19.0%	1.42 (0.73-2.78)	0.3

Data relate only to the workers who gave information (rate of withholding information was less than 10%)
*PR (95% CI): prevalence ratio with 95% confidence interval
**Two-tail Fisher exact test

sounds and hearing difficulties in noisy environments, respectively (Table 3).

Eleven variables were selected for the modeling process (logistic regression), in accordance with their statistical significance and/or relevance (Table 4).

The interaction term that was evaluated (age and length of exposure to occupational noise) was not significant, thus indicating that the effects of these factors were independent. The final model identified the variables of age and degree of use of individual protection equipment as significantly associated with cases suggestive of NIHL ($p<0.05$), after controlling for potential confounding factors (Table 5). According to the value of the likelihood ratio, the model was shown to be significant as a whole ($p<0.01$), and presented good adjustment quality, as assessed by the Hosmer-Lemeshow test ($p=0.65$).

DISCUSSION

The present study was conducted together with the company's Hearing Conservation Program, and a large proportion of the information was obtained by means of a questionnaire drawn up for this program. Thus, the survey had the burden of some limitations relating to the decision to work with data coming from a scheduled activity that was in progress. The priorities adopted for the program, with the aim of verifying the need for immediate assistance for the client companies, always gave consideration to the client companies to which the greatest contingents of workers were allocated. Since the data collection was restricted to a period of around five months, the program did not achieve 100% coverage over the period considered in its proposal for performing evaluations on all workers with potential exposure to noise in the working environment. At first sight, doubts could be raised regarding the representativeness of the study population. However, according to technical assessments by the SESMT, the workers who were not assisted through the Hearing Conservation Program during this period did not present conditions of exposure to occupational agents that differed from those of the other workers. Thus, it is believed that no significant selection bias occurred.

According to the bibliographic survey carried out, the prevalence of cases suggestive of NIHL found

Table 2 - Mean and standard deviation (SD), in years, of workers' ages and length of service in the company and their total length of exposure to occupational noise, according to the classification of the audiometric tracing.

Variables	Case suggestive of NIHL		p-value**
	Yes Mean (SD)	No Mean (SD)	
Age	50.2 (±12.3)	34.1 (±10.7)	<0.01
Length of service in the company	14.1 (±8.3)	6.4 (±6.5)	<0.01
Length of exposure to occupational noise*	16.6 (±11.2)	8.6 (±9.0)	<0.01

SD: Standard deviation
NIHL: Noise-induced hearing loss
*Data relate only to the workers who gave information (rate of withholding information was less than 10%)
**t test (difference in the means)

Table 3 - Percentage distribution of the population studied, prevalence of cases suggestive of noise-induced hearing loss and prevalence ratios, according to data on exposure to noise outside of the workplace, history of cranial trauma, morbidity in the worker and his family, auditory symptoms and smoking.

Variables	%	Prevalence	PR (95% CI)*	p-value
Exposure to noise outside of the workplace				
No	97.8	15.7%	1.00	
Yes	2.2	25.0%	1.59 (0.28-8.97)	0.5**
History of cranial trauma				
No	81.5	13.8%	1.00	
Yes	18.5	24.2%	1.76 (0.85-3.64)	0.14
Arterial hypertension				
No	87.6	15.5%	1.00	
Yes	12.4	22.7%	1.47 (0.62-3.45)	0.4
Diabetes mellitus				
No	94.4	15.6%	1.00	
Yes	5.6	30.0%	1.93 (0.70-5.29)	0.2**
Family history of hearing deficit				
No	82.1	18.3%	1.00	
Yes	17.9	3.2%	0.18 (0.02-1.25)	0.05**
History of smoking				
No	70.9	9.4%	1.00	
Yes	29.1	32.7%	3.46 (1.78-6.73)	<0.01
Buzzing sounds				
Never/ sometimes	98.3	15.3%	1.00	
Always	1.7	33.3%	2.17 (0.42-11.17)	0.4**
Hearing difficulties				
Never/sometimes	95.6	13.9%	1.00	
Always	4.4	62.5%	4.48 (2.33-8.60)	<0.01**

Data relate only to the workers who gave information (rate of withholding information was less than 10%)
*PR (95% CI): prevalence ratio with 95% confidence interval
**Two-tail Fisher exact test

in the present study (15.9%) was less than was found in all the other studies analyzed. These other studies presented a range of prevalences from 28.5 to 46.2%.[1,7,9,10,12,14,15] This observation needs to take into account the fact that these other studies were performed on different categories of Brazilian workers. In addition to this, the lower prevalence of cases suggestive of NIHL observed in the present study may also be related to the level of exposure to occupational noise that the workers studied were subjected to. This noise presented quantification difficulties at the individual level, due mainly to the nature of the activity performed: preventive maintenance (scheduled) and corrective maintenance (unpredictable).

The association between the cases suggestive of NIHL and age deserves highlighting, given that the prevalence of such cases rose as the age group increased (p<0.01). This occurred in an independent manner, and was around 11.45 times greater among workers aged over 50 years, in relation to workers aged under 30 years (95% CI: 3.57 to 36.73). This finding is consistent with the data in the literature.[1,2] The degree of use of individual protection equipment also presented a statistical association with cases suggestive of NIHL (p=0.02), after controlling for possible confounding variables. Thus, it was shown that there was a lower prevalence of cases suggestive of NIHL among workers who reported that they regularly used protection, in relation to those who said they used protection occasionally or not at all (PR: 0.56; 95% CI: 0.28-1.10). This emphasizes the need for individual protection equipment use to be indicated, made to fit and followed up when the collective protection measures are unsatisfactory.*

Even though length of service in the company (p=0.18) and positive history of cranial trauma (p=0.13) only presented marginal significance (0.05<p<0.2), they merit consideration because they are very relevant in the context of this illness and presented raw OR within the limits of the 95% confidence interval of the adjusted OR.

It was observed that the prevalence of cases suggestive of NIHL was greater for workers with more

Table 4 - Variables introduced during the modeling process, according to the respective selection criteria.

Variables	p-value
Significant (p≤0.05) and relevant	
Age group	<0.01*
Length of service in the company	<0.01
Length of exposure to occupational noise	<0.01*
Present and/or previous history of smoking	<0.01
Relevant, with marginal significance (0.05<p≤0.2)	
Family history of hearing deficit	0.05*
Degree of use of individual protection equipment	0.09
History of cranial trauma	0.14
Diabetes mellitus	0.2*
Relevant, without significance (p>0.2)	
Occupational exposure to chemical products	0.3
Arterial hypertension	0.4
Exposure to noise outside of the workplace	0.5*

*Two-tail Fisher exact test

*Ministério da Previdência e Assistência Social. Norma Técnica para Avaliação da Incapacidade – PAIR, de 5 de agosto de 1998. Aprova Norma Técnica sobre perda auditiva neurossensorial por exposição continuada a níveis elevados de pressão sonora. Ordem de Serviço INSS/DSS nº 608, Brasília (DF); 1998.

Table 5 - Raw and adjusted odds ratios (final logistic regression model) and the respective 95% confidence intervals.

Variables	Raw OR (95% CI)*	Adjusted OR (95% CI)*
Age group		
Up to 29	1.00	1.00
30 to 39 years	1.30 (0.21-8.12)	0.92 (0.11-7.75)
40 to 49 years	6.00 (1.52-23.61)	12.48 (1.93-80.75)
50 and over	21.25 (5.49-82.29)	22.62 (3.12-163.89)
Length of service in the company		
0 to 5 years	1.00	1.00
6 to 10 years	4.52 (1.33-15.42)	5.00 (1.00-24.93)
11 to 20 years	5.86 (1.95-17.58)	4.40 (0.93-20.75)
20 years and over	11.08 (3.11-39.48)	3.60 (0.48-26.96)
Length of exposure to occupational noise		
0 to 5 years	1.00	1.00
6 to 10 years	1.83 (0.49-6.80)	0.31 (0.05-2.09)
11 to 20 years	2.75 (0.84-8.97)	0.26 (0.04-1.58)
20 years and over	6.95 (2.41-20.03)	0.32 (0.04-2.38)
Degree of use of individual protection equipment	0.50 (0.22-1.12)	0.30 (0.11-0.84)
History of cranial trauma	2.00 (0.79-5.05)	2.46 (0.76-7.92)

*OR (95% CI): odds ratio with 95% confidence interval

than six years of service in the company than for those with shorter service. This finding may indicate that various working environments within the production sectors of the client companies may be contributing towards the occurrence of this hazard to workers' health. The prevalence of cases suggestive of NIHL was around 1.8 times greater among workers with a positive history of cranial trauma than for those who were negative for such trauma. This is in accordance with the need to investigate this factor when there are workers with a hearing deficit suggestive of NIHL, so as to gain a better etiological understanding.[2,*]

The length of exposure to noise in the working environment was shown to be not significant in the adjusted model (p=0.48), thereby indicating the influence of the other variables on the raw measurement. This finding may be explained by the fact that this variable, which was reported by the workers, is very subject to information bias. It may be overestimated or underestimated due to a variety of interests, such as the obtaining of some legal assistance. It is worth commenting that the average length of exposure to occupational noise that was reported (9.9 years) was greater than the average length of service in the company in question (7.6 years), which may suggest prior exposure to noise in previous activities.

Although the statistical results indicated independence between age and length of exposure to occupational noise, the possibility of collinearity can only be eliminated by pairing the study participants by age, under different exposure conditions, which was not done in this case. It also needs to be taken into consideration that, even though the association between exposure to chemical products and NIHL was not significant in the present study (p>0.05), the lack of exposure measurement results and lack of detailed exposure history do not allow such an association to be dismissed.

Even with all the limitations already discussed, the present study has enabled better comprehension of the behavior of some of the principal characteristics that are related to NIHL, in a particular situation of the organizing of work that is relatively common in the industrial environment. Similar studies undertaken in the future will certainly enable an ever-closer interpretation of the real situation of Brazilian workers. Every approach undertaken must always be placed within its context, because of the diversity of occupational health questions in Brazil and the difficulties in researching this field in this country. Such investigations not only involve various problems of a technical nature, but also financial interests and significant legal implications.

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