Occupational noise as a risk factor for work-related injuries

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Abstract

Objective
To assess whether exposure to occupational noise is an important risk factor for work-related injuries.

Methods
A population-based case-control study was performed. Data collection was carried out from May 16, 2002 to October 15, 2002 in the city of Botucatu, southeast Brazil. Cases were defined as workers who had suffered typical work-related injuries in a 90-day period previously to the study, and who identified through systematic random sampling of their households. Controls were non-injured workers randomly sampled from the same population, matched on 3:1 ratio according to sex, age group and census track. A multiple logistic regression model was adjusted, where the independent variable was exposure to occupational noise, controlled for covariates of interest.

Results
A total of 94 cases and 282 controls were analyzed. An adjusted multiple regression model showed that "work always exposed to high-level noise" and "work sometimes exposed to high-level noise" were associated to a relative risk for work-related injuries of about 5.0 (95% CI: 2.8-8.7; p<0.001) and 3.7 (95% CI: 1.8-7.4; p=0.0003) respectively, when work not exposed to noise was taken as a reference, controlled for several covariates.

Conclusions
Based on the study findings, investing in hearing conservation programs, particularly those for controlling noise emission at its source, is justifiable aiming at both hearing health maintenance and reduction of work-related injuries.

INTRODUCTION

Work-related injuries are the major cause of impairment among Brazilian workers. They represent a key public health concern in both developing and developed countries. Unlike other accidents, work-related injuries are not either fortuitous or accidental events,[20] but actually preventable socially-driven[7] phenomena.

In the 70's, the specialized international literature pointed out to the fact that workers exposed to high-level occupational noise were three to four times more likely of being injured at work when compared to non-exposed workers.[4] It has also been noted that the implementation of Hearing Conservation Programs (HCP) for workers exposed to occupational noise, aimed at preventing exposure and hearing damage. Besides that, these programs have significantly reduced the risk of injury.[2,5]

The purpose of the present study was to assess whether exposure to occupational noise is an important risk factor for work-related injuries.

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METHODS

The present study was part of a large research to assess underreporting of work-related injuries.[6] The investigation was conducted in Botucatu, a city with a population of 130,000 inhabitants in southeast Brazil.

A population-based case-control study was carried out to investigate whether occupational noise exposure was an important risk factor for work-related injuries. The study base population comprised economically active individuals living in the city of Botucatu. Cases were defined as workers who lived in the city and had work-related injuries in the last 90 days previously to the study. Subjects were identified through systematic random sampling of households in the urban area of Botucatu, where 94.6% of the economically active population live.

The sampling process and the following household interviews were conducted from May 16, 2002 through October 15, 2002, in 195 urban census tracks of the city of Botucatu. First, all households were listed and then 10,311 were sampled. Of them, there was no response in 650 (6.3%) households in three consecutive visits, so they were excluded from the sample with no replacement. In 33 (0.3%) of the households sorted out, the adult dweller who had answered the door refused to participate in the study, and their households were thus excluded from the sample with no replacement. As a result, the study sample comprised dwellers of 9,626 households.

For each case identified, three controls were randomly selected from a population of active non-injured workers for the same period, from a listing compiled in the process of case identification and matched by sex, age group (age ±1 year old) and census track. As each case was being identified and interviewed, controls' identification and data collection were continuously carried out throughout the sampling process.

After having been informed of the study purposes and signed their consent to be enrolled in the study, cases and controls were interviewed by trained field staff, who administered a questionnaire comprising several occupational and non-occupational questions. Noise exposure in the work environment was ascertained through a close question, "Do you work in a noisy setting?", which accepted three different answers: "yes", "no" and "sometimes". Workers have been instructed to deem a work environment very noisy when they could not hear their co-workers as they spoke naturally. The answer "no" was set as a point of reference, and then this variable was categorized according to two dummy variables, "work always exposed to high-level noise" and "work sometimes exposed to high-level noise".

The questionnaire also collected information on the following variables:
- Schooling: discrete variable providing the complete years of education.
- Type of job: dichotomous categorical variable providing information whether the worker was formally hired or not.
- Mean daily working hours in the last 90 days: continuous variable, measured in hours.
- Mean weekly overtime hours in the last 90 days: continuous variable, measured in hours.
- Number of co-workers in the same work division: discrete variable.
- Work shift: categorical variable providing the work shift worked in the last 90 days, categorized as "fixed day shift", "fixed night shift" and "alternate shifts". "Fixed day shift" was set as a point of reference, and then this variable was categorized by two dummy variables, "night shift work" and "alternate shift work".

Detailed information on the study subjects' current occupation was also collected in the interview. Based on that, cases and controls' occupations were grouped according to nine main groups of the Brazilian Classification of Occupations[12] (CBO, 2000). The large job group "scientists" was set as a point of reference, and then this variable was categorized into eight dummy variables: police officers, managers, technicians, managerial workers, utility workers, farmers, blue-collar workers, and maintenance workers.

For the statistical analysis, univariate models of conditional simple logistic regression[11] were first adjusted, with a 1:3 matching ratio, having as dependent dichotomous variable the occurrence of an injury event (control =0, case =1) and as independent variable each one of the variables mentioned above.

Then, the conditional multiple logistic regression model[11] was adjusted, with a 1:3 matching ratio, where the dichotomous categorical dependent variable was the occurrence of an injury event (control =0, case =1) and independent variables were those yielding odds ratio estimates for a p-value equal or less than 0.25.[18] Adjusting was carried out using the backward method at a 5% significance level.[11] The identification of the study variables as risk for work-related injuries, were made through incidence risk ratio estimates obtained in the adjusted analysis. These estimates were made possible by the actual choice of the study design.[16]

Table 1 - Distribution of injured workers by sex and age in the case-control study, Botucatu, 2002.

| Age groups (years) | Sex | | | | Total | | |
| | Female | | Male | | | | |
	Abs. freq.	Rel. freq. (%)	Abs. freq.	Rel. freq. (%)	Abs. freq.	Rel. freq. (%)	Cumulative relative frequency (%)
10-19	0	0.0	11	1.1	11	1.1	11.7
20-29	5	5.3	18	19.1	23	30.9	35.1
30-39	5	5.3	28	29.8	33	41.5	70.2
40-49	4	4.3	11	11.7	15	21.3	86.2
50-59	2	2.1	8	8.5	11	11.7	97.9
60-69	1	1.1	0	0.0	1	1.1	98.9
70-79	0	0.0	1	1.1	1	1.1	100.0
Total	17	18.1	77	81.9	94	100.0	—

The present study was approved by the Research Ethics Committee of Botucatu Medical School, Unesp.

RESULTS

In the sampling process there were identified a total of 198 non-fatal injuries in a 90-day period previously to the household interview. Of these, 109 were described as work-related, of which 94 (86.2%) were typical and 15 (13.8%) route-related injuries. The remainder 89 injuries were categorized as non-occupational car accidents, home accidents and others.

Table 1 show the distribution of all typical injuries by sex and age group. Note that 35% of these injuries affected young adults aged 30 years or less, and more than 10% aged 20 years or less.

Most injuries studied included cuts, bruises, fractures and acute joint lesions. The primarily body sites affected were hands, followed by upper limbs, head (except for the eyes), and lower limbs (except for feet). Direct injury agents were mostly machines and equipment, falls from one's height, car accidents and falls of objects. Work-related injuries were mostly mild or moderate, and in 85 cases (90.4%) it required sick leave for up to 15 days.

All work-related injured workers identified in the sampling step agreed to participate in the study. They were matched with 282 non-injured controls according to the criteria described before, making it a total of 376 workers enrolled in the study.

Through univariate logistic models, p-values below 0.25 were found for variables such as work always exposed to high-level noise, work sometimes exposed to high-level noise, schooling, mean working hours, mean weekly overtime, number of co-workers in the same work division, alternate shift work and blue-collar workers. These adjusted analyses are shown in Table 2.

A multivariate logistic model was built up using the variables mentioned before. It was found for the variables "work always exposed to high-level noise", "work sometimes exposed to high-level noise", which were selected as risk factors of work-related injuries, adjusted odds ratio of 5.0 (p<0.0001, 95% CI: 2.8-8.7) and 3.7 (p=0.0003, 95% CI: 1.8-7.4), respectively. Table 3 shows statistical analysis for the adjusted model. Odds ratio estimates for other variables stud-

Table 2 - Estimates obtained from the univariate logistic models analyzing global risks for work-related injuries in the case-control study, Botucatu, 2002.

Variable	β_1 estimate	p-value	Odds ratio	75% CI
Schooling	-0.0499	0.1402	0.951	0.915-0.989
Type of job	-0.2472	0.3406	0.781	0.580-1.053
Mean daily working hours	0.0225	0.0687	1.023	1.008-1.037
Mean weekly overtime	0.0659	0.0698	1.068	1.024-1.114
Number of co-workers in the same work division	0.0015	0.0093	1.001	1.001-1.002
Work in alternate shifts	0.4295	0.1663	1.536	1.075-2.195
Work in night shifts	0.3859	0.4773	1.471	0.788-2.747
Work always exposed to high-level noise	1.2864	<0.0001	3.620	2.693-4.285
Work sometimes exposed to high-level noise	0.6597	0.0371	1.935	1.344-2.784
Police officers	1.2698	0.3358	3.560	0.781-16.237
Scientists	0.5410	0.3479	1.718	0.885-3.333
Technicians	0.0430	0.9168	1.044	0.650-1.676
Managerial workers	-0.6004	0.2851	0.549	0.287-1.047
Utility workers	-0.3283	0.3289	0.720	0.489-1.060
Farmers	0.5321	0.4020	1.708	0.819-3.560
Blue-collar workers	0.4830	0.0685	1.621	1.195-2.199
Maintenance workers	-0.2213	0.6470	0.801	0.460-1.397

Table 3 - Estimates obtained from the multivariate logistic model analyzing global risks for work-related injuries in the case-control study. Botucatu, 2002.

Variable	β_1 estimate	p-value	Odds ratio	95% CI
Continuous exposure to high-level noise	1.6004	<0.0001	4.955	2.817-8.716
Intermittent exposure to high-level noise	1.2974	0.0003	3.660	1.817-7.370

χ^2 likelihood ratio =45.3356, 3 degrees of freedom, p-value<0.0001

ied yielded results with a p-value higher than 0.05 and therefore were excluded in the adjusted analysis. There was no statistically significant interaction between the selected variables at a 5% significance level. After examining the residuals of the adjusted analyses no violations of the logistic model assumptions were verified.

DISCUSSION

The likelihood of a work-related injury is not homogenously distributed throughout different categories of workers having different jobs and tasks. Jobs and tasks are distinctive regarding the level of risk exposure. Noisy work environments often involve risks for occupational injuries other than the exposure to noise per se. This is the reason why, in the multiple logistic analysis, risk estimates were controlled for variables such as schooling and large job group, among others, in an attempt to control confounding resulting from non-comparability of jobs between cases and controls. In fact, the adjusted risk estimates associated to the variables "work always exposed to high-level noise" and "work sometimes exposed to high-level noise", as shown in Table 3, proved to be significantly different from the crude estimates, shown in Table 2, which is suggestive of confounding.

As shown in Table 3, the adjusted analysis of the variables "work always exposed to high-level noise" and "work sometimes exposed to high-level noise" were identified as risks for work-related injuries. These estimates were controlled for sex, age group, census track (due to matching), as well as occupation, schooling, shift work, hired work, working hours, overtime hours and alternate shift work (due to the analysis). The backward method for variable selection was used as no explanatory model was available.

In his review study, Kjeliberg[13] reports that high-level noise in the workplace is associated to high rates of work-related injuries.

Barreto et al,[1] in a case-control study nested within a cohort study of metalworkers conducted in Brazil between 1977 and 1990, found a significant association between exposure to industry-related noise and fatal work-related injuries, after adjusting for confounders.

In a case-control study among shipyard workers in the Netherlands from 1986 to 1987, Moll van Charante & Mulder[15] verified an association between a exposure to industry-related noise above 82 dB and work-related injuries. The odds ratio of this association was estimated as 1.8 (95% CI 1.2-2.9) after adjusting for confounders. They also observed that no such association was found in workers who had already had hearing loss.

Melamed et al[14] verified in a 1992 cross-sectional study carried out among 2,368 factory workers an association between noise level above 85 dB and work-related injuries. Similarly, in a recent study, Berger et al[2] stressed that workers working with no hearing protection in noisy environments are more likely to be injured.

Occupational noise compels workers to inducers of work-related injuries such communication barriers (impairing detection, discrimination, localization, identification of noise sources as well as speech understanding),[2,10] attention and concentration problems[3,17] and memory impairments[3] as well as stress[8,9,14,19] and extreme fatigue.[8,17]

It should be stressed the magnitude of odds ratio estimates found in the study. The relative risk of having an injury for those workers sometimes exposed to high-level noise was 3.7 (1.8-7.4) compared to 5.0 (2.8-8.7) for those workers always exposed to high-level noise, which are higher than those described in the literature. Such finding calls for hearing conservation programs, especially for controlling noise emission at their sources, aiming at preserving hearing health but also at reducing workers odds of being injured.

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