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Noise perception and hearing protector use in metallurgical industries

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Abstract

Although hearing protectors are defined as a temporary solution, they are often widely employed as the only measure against noise exposure. However, it is also known that unless workers wear the hearing protector continuously, their effectiveness will be very low. In this regard, there are some surveys that show that workers do not always wear their protectors properly and consistently while exposed to noise. The purpose of this article is to present the results of an investigation about noise perception, relating with noise exposure in working environment and the hearing protectors' use. Was consider that noise perceptions effects can support minimizing risk and improve industries safety polities. The study sample was carry out in 5 metallurgical industries and 243 workers from Parana – Brazil. The survey data was collected and analyzed by Statistical Package for the Social Sciences (SPSS). The questionnaire results showed that workers are exposed at high noise levels, in increasing risk of developing noise-induced hearing loss (NIHL). About the hearing protection use, it can be evaluated that the use is more effective in companies with a higher level of noise exposure. The perception of risk plays a fundamental role, which predicts the use of hearing protectors; therefore, the perception of the work environment, regarding the lower or higher risk, can be directly linked to the use of hearing protectors. The companies with more rigorous safety procedures also indicate a greater report of effective use of hearing protectors.

1. INTRODUCTION

Workers exposed to high noise levels are at risk of noise-induced hearing loss - NIHL (Ahmed et al., 2001). The occupational noise level is a permanent concern in all regions, being the major cause for the incapacitating deafness in the world (Reddy et al., 2012), is a public health problem with many social and economic consequences (Lie et al. 2015), and despite the imposed regulations and standards, occupational hearing loss persists.

According European Communities one out of five workers in Europe must raise his voice to be heard for more than half the working day and a 7% of them suffer from hearing problems related to work. According to European data (2004), the loss of hearing caused by the noise is the most common occupational illness in the European Union.

The prevalence of NIHL is also high in developing countries, such as Brazil. Miranda et al. (1998), evaluated 7.925 workers from 44 industries of different industries, found a general prevalence of NIHL around 36%, and in the metallurgical sector the hearing loss found was 43.6%. Manubens (1994) has found pathology in 23% of the 32.007 workers in 150 manufacturing industries in 16 Brazilian states.

Sensorineural hearing loss is a result of exposure to high noise levels that is linked not only to exposure time, but also to noise characteristic (frequency, intensity), nature (continuous or floating noise) characteristics that may affect the degree of hearing deficiency.

In addition, the level of hearing loss tends to increase with age, however, the trend line is higher in workers exposed to high occupational noise, and becomes even more significant if there is no continuous use of hearing protectors (Araujo, 2002; Hunashal & Patil 2012; Whittaker et al. 2014).

For many industries, the actions of hearing conservation are summarized in the application of hearing protectors. According Stephenson et al. (2011), the implementation of an effective hearing conservation program should be established after determining the factors that substantially influence the real use of hearing protection by workers. The program and the measures that will be taken should be planned together, with all the company's staff, so that the actions are punctual, and really are effective in protecting workers.

In this way, companies must invest in efficient hearing conservation programs to promote a safer and more comfortable working environment. Educational training programs and training are also important (Stephenson & Stephenson 2011, Bockstael, et al. 2013) for the awareness of workers. The organizational climate is essential to promote the effective use of auditory protectors (Lusk, et al. 1998, Arezes & Miguel 2005), as well as rigid and well-structured policies and practices on safety and auditory conservation among all employees.

The aim of this paper is to analyze individual aspects of noise perception, and the use of HPDs. Identifying the factors that contribute to perception and how perception influences particular safety behaviors. This study contributes to the understanding of factors that may influence the use of the hearing protector.

2. HEARING PROCTETORS USE

A personal hearing protection device (or hearing protector) is an acoustic barrier to protect the ear and reduce the level of airborne sound that reaches the eardrum (Miranda, 2003). The main purpose of hearing protectors is to reduce, to an acceptable level, excessive levels of noise. These devices are easily implemented, as they are low cost methods that minimize hearing loss by continuous exposure to high intensity noises.

When workers are exposed to excessive noise levels, administrative or engineering control are recommended to reduce its. Therefore, when these techniques are not available immediately, the equipment can be used, but this type of solution should not be considered definitive, due to the intrinsic characteristics of the protectors, such as poor comfort, difficulty in verbal communication (Gerges, 1992).

Some authors point out barriers about comfort to the use of the protectors (Melamed et al., 1996; Davis et al., 2009; Byrne, 2011). Others research point the relationship between hearing protection use and risk perception in the work environment (Rabinowitz et al., 2007) and indicate that the most effective use of hearing protection in the workplace is more related in places where noise exposure is higher. According them, the perception of risk is higher in these environments.

Arezes and Miguel (2006) suggests that supervision helps to improve the use of hearing protection, but does not lead to increased perception of risk. According to the authors, perception of risk is also quite high in companies with more rigid safety policies, although somewhat lower than in industries with higher levels of exposure.

3. MATERIALS AND METHODS

3.1 Data collection procedures

To develop an analysis about the noise perception and the hearing protection use, 243 workers from four medium-sized and one large metallurgical enterprises in Parana State - Brazil were interviewed. Company size was measured by the number of employees, one of the most common measures.

The European Commission defines micro enterprises as those with 0-9 employees, small businesses with 0-49 employees, medium-sized companies with up 250 employees and large enterprises with 250 or more persons employed (Laforet 2013).

One of the main points for choosing the sample of employees to participate was to determine the areas with a higher incidence of noise. The selection of the sample considered the noise levels reported by the company, since it was

intended that the sample was exclusively composed of workers exposed to noise above 85 dB (A), (above the levels allowed for daily exposure without protection established by Brazilian Legislation).

The data collection was performed in four steps: (1) workers selection (which were working in environment with level up than 85 dB (A). (2) Interview (first, general data were collected: age, sector of working, service time in the same sector and educational level. (3) Collection of noise levels (informed by company) (4) Interview (main questionnaire/employees).

To select the sample study, some inclusion and exclusion criteria were applied: Inclusion – agree voluntary to participate in the survey; be working in the same sector at least 1 year. Exclusion – working in environment with levels below 85 dB (A), according Brazilian regulatory limits, which limit value is 85 dB (A) for eight hours, and the maximum dose of 100% were used. In sequence, data collected were analyzed.

The data were analyzed through descriptive statistics. First, Cronbach's alpha (α) was used to test the internal reliability of the questionnaires' scales.

The Levene Test was used as recommended to evaluate if the variances of a single metric variable are equal between groups. Variance Analysis - ANOVA is used to verify if there was a systematic difference between the means of results (Vieira & Ribas, 2011).

To test the significance of the ANOVA results, the Tukey test was opted, since it is considered "one of the most robust deviations from normality and homogeneity of variances for large samples" (Maroco, 2014).

This study was approved by the National Commission of Ethics in Research (CONEP) under the number 53661315.4.0000.5547. All selected workers in this research signed a voluntary commitment agreement.

3.2 Interviewees and questionnaire

At first, for identification of the companies and future comparisons, other general questions were asked, such as activity sector, number of employees and noise levels.

One of the researchers conducted the interviews personally in the months from March to June 2016. As agreed, the enterprises names will not be revealed, so, letters identify them.

In the employees' questionnaire asked about noise individual perception source of noise; self-efficacy perception; noise effects perception; risk behavior and hearing protector use.

The questions were made using a Likert scale questionnaire, this method was developed by Arezes (2002), and the ranking perception answer used ranges from 1 = no risk to 5 = too much risk, and, 1 = totally disagree to 5 = totally agree.

Individual risk perception is an important antecedent for risk behavior (Diaz & Resnick, 2000; Glendon & Stanton, 1995) the way that workers perceive the risks they are exposed can be an important factor for a better understanding of risk management (Arezes & Miguel, 2005).

The Risk Behavior Assessment verifies workers' risk behaviors, such as actions that violate safety rules and procedures, as well as items related to non-use of hearing protectors. The risk behaviors were analyzed between companies, to verify differences between them and the level of noise exposure.

The questionnaire applied to workers provides questions that assess the individual perception of noise treated as follows: perception about sources of risk; perception of self-efficacy; perception about noise effects; and risk behavior.

4. RESULTS

4.1 Interview questions and answers

The general data shows the population profile that was found in the sample study.

Table 1 shows the distribution of the 5 companies surveyed that were identified through letters (A) through (E), followed by the total number of employees, the number of the sample that was surveyed, followed by information that refers to the average age of employees of each company, and the working time in the same sector (in years) in each company.

It is important to note that the data related to the work time are related to the time that employee works in the same sector - and not the total work time in the company. This criterion was adopted to better evaluate the time (years) of exposure to noise that, the workers are exposed to.

It is possible to observe that the companies participating in the study have different sizes. Concerning the age of the workers and work time in the respective companies, it possible to verified that, companies (A) and (B) have a longer period of employment, between 8 - 9 years of work and the average workers age is also higher.

In the same table are reported the types of hearing protectors used by workers in each company. The use of the ear protector was reported by 100% of the workers surveyed in the companies.

Note that, plug type is the most used, and in company (D) there is only one option of hearing protection equipment.

Table 1. General data of the companies interviewed

Company	Employees Number	Sample number	Age Average	Sd	Service time	Sd	HPD ear plug	HPD earmuffs
A	385	58	40.8	11.1	8.9	6.0	79%	21%
B	80	43	37.6	12.5	7.9	6.8	93%	7%
C	720	89	38.9	11.5	7.1	7.3	87%	13%
D	165	19	31.5	8.4	4.3	4.5	100%	0%
E	220	34	34.5	9.7	4.6	5.4	56%	44%

However, it is analyzed that a significant number of workers (43% of respondents) are exposed to occupational noise over 85 dB (A) for more than 6 years.

In a survey carried out in metallurgical companies in Brazil, Guerra (2005) found that the prevalence of cases suggestive of Noise Induced Hearing Loss – NIHL rises from six years of activity in the company, compared to workers with shorter working hours.

4.2 Occupational noise exposure

According NR-9 (MTE, 2011) establishes the obligation to elaborate and implement the Environmental Risk Prevention Program - which according to the Standard considers the physical agents (noise, vibration, pressure, temperature, and radiation), chemical and biological, depending on their nature, concentration or intensity, can cause harm to the worker's health.

Due to the obligatoriness, annually the companies make the measurements in the levels of noise in the workplace. Therefore, the noise level was obtained through information from the Program for the Prevention of Risks and Accidents - PPRA of the company surveyed.

The results of company noise levels are presented (Table 2).

Table 2. Percentage of workers exposed to noise levels exceeding 85 dB (A)

Noise Levels dB (A)	A	B	C	D	E
85 - 86	10%	0%	24%	0%	68%
87 – 89	28%	40%	48%	16%	26%
90 – 92	26%	58%	25%	84%	6%
93 - 98	36%	2%	3%	0%	0%
Sample	**58**	**43**	**89**	**19**	**34**

We can observe that, in company (A) and (D), noise levels are very high and there are many workers exposed in this environment. In the other hand, company (E) has lower noise levels comparing with the other.

Referring to the use of hearing protectors, a brief analysis is important. The company (E) has the lowest noise level among those surveyed; however, this company offers options for protectors, 44% of employees of this company use HPD earmuffs (table 1). Already in company (D), where a considerable number of workers are exposed to levels above 90 dB (A) there is no option of hearing protector provided to workers.

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4.3 Noise perception

Individual risk perception and other perceptual-cognitive factors are important predictors of workers' safety behavior, as the use of hearing protection (Arezes & Miguel, 2005).

In this research was analyzed the workers perception about sources of noise.

According Arezes and Miguel (2005) workers seem to use hearing protection based on their perceived level of risk. In this way, it is possible to analyze the perception in different companies, as shown Table 3.

Table 3. Results sources of noise perception

Company	N	Alpha = 0.05	
		1	**2**
E	34	**25.29**	
B	43	26.26	
C	89	26.69	26.69
A	58	27.59	27.59
D	19		**29.89**
Sig.		0.304	0.056

Results showed that in companies (A) and (D) workers had a higher perception of risk from noise sources, while in companies (E) and (B) there was a lower perception of risk.

The perception of efficacy is also an important guideline for research. This question evaluated the perception of the workers' self-efficacy in relation to the hearing protector: the correct and efficient use of the hearing protector; Knowledge and effectiveness of HP.

The highest score indicates greater perceived self-efficacy, results of Turkey Test are present (Table 4).

Table 4. Results perception of self-efficacy in different companies

Company	N	Alpha		
		1	**2**	**3**
B	43	**27.55**		
C	89	27.78	27.78	
D	19	28.26	28.26	28.26
A	58		29.79	29.79
E	34			**30.00**
Sig.		0.893	0.076	0.169

The company (E) registers a greater perception of self-efficacy among the companies surveyed. One factor that may influence perceptions is that the company (E) as shown in Tables 1 and 2 shows less noise in the work environment and workers can choose different types of hearing protectors.

4.4 Perception of noise effects

Unlike other contaminant agents, the effects of noise may be unnoticed instantaneously and its accumulation can lead to an obvious physical, psychic and social deterioration. The best studied effect of the overexposure to noise is the loss of hearing.

The problem is that the exposed people are scarcely aware of the cause-effect relation given that it is produced slowly but progressively. Therefore, this study evaluated the perception of workers regarding the effects of noise.

Hearing loss can also be affected by age, the permanent hearing threshold increases progressively, and hearing loss is even higher for the higher frequencies. The older the workers, the harder it becomes to distinguish the combined effects of deafness by age.

Table 5. Results noise perception effects and worker age

Age	N	Alpha = 0.05	
		1	**2**
18 - 22	**19**	**15.73**	
28 - 32	38	16.97	
23 - 27	37	17.72	
33 -37	30	18.80	
38 - 42	30	20.03	
43 - 47	28	20.71	20.71
48 - 52	32	21.78	21.78
53 - 57	17	23.17	23.17
More than 58	**12**		**28.25**
Sig.		0.056	0.05

Therefore, was evaluated the responses about the perception of the effects of noise on workers and compared to the age of the worker. Analysis of variance found that there is a significant difference ($p < 0.001$) between the average results usually distributed between the workers age and answers about noise effects perception as shown in Table 5.

It is possible clearly assess a trend line on the perception of the effects of noise on the younger to the older workers.

The same analysis was performed between working time and the perception of noise effects. In the same way, it was found through the analysis of variance significant difference ($p < 0.001$) between the average results (Table 6).

Table 6. Results noise perception effects and work time in the same sector

Work time (years)	N	Alpha = 0.05
		1
At least 1 year	**40**	**16.20**
2 years	36	16.88
Between 3 to 5 years	61	19.29
Between 11 to 15 years	18	20.38
Between 16 to 20 years	26	21.46
More than 20	10	22.30
Between 6 to 10 years	**52**	**22.96**
Sig.		0.071

The level of hearing loss tends to increase with age, however, the trend line is higher in workers exposed to high occupational noise, and becomes even more significant if there is no continuous use of hearing protectors.

4.5 Risk behavior

The risk behavior was evaluated, so it was possible to verify differences between companies and the level of noise in which the worker is exposed.

Through the ANOVA and Levene results it can be verified that there is a systematic difference ($p<0,001$) between the means of risk behavior among companies.

The Tukey test Analyzes where these differences are, which can be analyzed in Table 7.

Table 7. Tukey Test for risk behavior in different industries

Company	N	Alpha = 0.05	
		1	2
A	**58**	**6.94**	
D	19	7.68	7.68
B	43	7.79	7.79
C	89	8.44	8.44
E	**34**		**9.73**
Sig.		0.49	0.18

The lowest risk behavior was identified in company (A) and company (D), and the highest risk behavior index in company (E) and (C).

Analysis of variance found that there is a significant difference ($p < 0.001$) between the average results usually distributed between the noise level exposure and answers about risky behavior.

It was noted that there is a significant difference between the means that relate the worker's risk behavior and the level of exposure noise. These differences can be observed through the Tukey Test expressed in the Table 8.

Table 8. Results for risk behavior in different noise level exposure

Noise Level (dB (A))	N	Alpha = 0.05	
		1	**2**
Up than 90	39	**6.43**	
87 to 88	34	7.47	7.47
89 to 90	48	8.35	8.35
85 to 86	33		**9.36**
Sig.		0.12	0.13

The results showed that there is a higher risk behavior in workers who are exposed to noise levels between 85 dB (A) and 86 dB (A), and there is a lower risk behavior in workers exposed to noise above 90 dB (A).

4.6 Hearing protection use

Some research has shown that few workers use hearing protection devices throughout their working time (Williams, et al. 2004; Ahmed 2012). Therefore, in this research the verification between the self-report of the use and the effective use was performed, for this, two questions were analyzed: "I do not always use the protectors as it should" and "My colleagues do not usually use protectors".

It was found that the variation ($p < 0.001$) is significant for the question "my colleagues do not usually wear protectors". The differences were analyzed through the Tukey Test, in order to identify in which groups, the differences are located.

Table 9 shown the results, it is possible to notice that the report of hearing protector use of colleagues is greater in the environment with noise above 90 dB (A) and being smaller in the environment between 85 and 86 dB (A).

Table 9. Results for "my colleagues do not usually wear protectors" compared to noise levels

Noise Level dB (A)	N	Alpha = 0.05	
		1	**2**
Above to 90	62	**1.76**	
87 to 88	47	1.87	
89 to 90	84	2.17	2.17
85 to 86	50		**2.68**
Sig.		0.344	0.15

The same way, was analyzed the differences between companies. There were differences between the report of hearing protectors use and the report of use by colleagues among the different companies. The results are presented (Table 10).

The company (C) presented smaller difference between the two answers. It is understood that the responses of self-report of use and the use by colleagues are practically equivalent. A close result also recorded by company (A). It is important to mention that both companies (A) and company (C) recorded high noise level.

The company (E) registered a greater discrepancy between the conflicts of the two responses, thus, the hearing protector use is not similarly related to the reports that the colleagues answered. At this point, it is important to note that the company (E) has the lowest levels of noise among the companies surveyed, and it can be evaluated that the use is more effective in companies with a higher level of exposure to noise.

Table 10. Results for "my colleagues do not usually wear protectors" compared to different companies

Company	N	Alpha = 0.05	
		1	**2**
C	89	**1.80**	
A	58	1.97	
D	19	2.00	
B	43	2.40	2.40
E	34		**2.88**
Sig.		0.282	0.49

According Arezes & Miguel (2005) the perception of risk plays a fundamental role, which predicts the use of a hearing protector, therefore, the perception of the work environment, about lesser or greater risk, can be directly connected with the hearing protector use.

5. CONCLUSIONS

Understanding workers' perceptions, the safety culture of a workplace, and attitudes are important factors in assessing safety needs. The perception about the risk addressed through the questions, seek mainly to understand the dimension of the perception of risk and to relate among the companies surveyed.

There were differences in risk behavior among companies surveyed. The company (E) registered the highest risk behavior index, in this company the lowest noise was found (between 85 and 86 dB (A)) when compared to the other companies surveyed. This factor can strongly influence the perception of "non - risk". Another important consideration is that, the company (E) 41% of employees makes use of the hearing protector earmuffs, which can improve the perception of hearing protection.

Already in company (A) was identified lower risk behavior among the companies surveyed.

To confirm this evaluation, it is possible to relate the behavior of risk with the level of exposure to noise of the workers.

In this perspective, there was a significant difference between the means, and it was observed that the lowest risk behavior index is located in workers who are exposed to noise levels higher than 90 dB (A), while the highest risk behavior index was found in the group of workers exposed to noise levels between 85 and 86 dB (A).

Was concluded in this research that, in an occupational environment where high levels of noise are recorded, workers tend to comply more strictly with the use of hearing protectors, and the annoying level of noise can motivate workers to use the equipment if compared with workers in areas with less exposure to noise.

Workers exposed to higher noise can have lower risk behavior, while workers exposed to lower noise tend to be at higher risk behavior.

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