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Original articles

Impact of a hearing conservation programs on occupational noise-induced hearing loss

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ABSTRACT

Purpose: to analyze the impact of a Hearing Conservation Program on occupational noise-induced hearing loss in a metallurgical plant.

Methods: a longitudinal case study (2003-2018) was carried out and a Hearing Conservation Program assessed with interviews and document verification. The assessment also included 2,350 audiometric examinations and occupational noise exposure of 152 Hearing Conservation Program - participating employees, collecting the data from the company's database.

Results: high compliance indices regarding occupational noise -induced hearing loss - prevention Hearing Conservation Program practices were found between 2003 and 2018. The comparison between 2018 and 2003 showed a reduced number of workers exposed to noise at 85 dB(A) or above. The final prevalence of audiometric changes suggestive of occupational noise-induced hearing loss that remained in degree I differed from the initial one in the period. The high Hearing Conservation Program percentages and low occupational noise-induced hearing loss indicators point to an inverse relationship between them.

Conclusion: the results suggest a positive impact of a Hearing Conservation Program on occupational noise-induced hearing loss in this metallurgical plant, in the period studied.

Keywords: Public Health; Occupational Risks; Occupational Health Program; Hearing Loss, Noise-Induced; Prevalence

INTRODUCTION

Occupational noise-induced hearing loss (ONIHL) is one of the most recurrent occupational health conditions, characterizing it as a public health issue. In various industries, particularly ironworks, metallurgy, printing, textile, paper, glass, and so forth, workers are exposed, daily, to high sound pressure levels – i.e., loud noise[1].

Self-reported occupational noise exposure in Brazil has a prevalence of 32.1%[2]. In the converting industry, at least 45% of workers are exposed to noise in their activities[3].

In a strategy to address ONIHL, the Ministry of Labor and the Ministry of Social Security determined that companies whose employees are exposed to high sound pressure levels must implement Hearing Conservation Programs (HCP)[4,5].

HCP is a set of planned, dynamic, systemic, integrated, interdisciplinary, and multiprofessional measures taken to prevent and stabilize ONIHL. Basically, this set of measures comprises collective and individual noise-exposure control measures, educative measures, auditory surveillance, and program effectiveness assessment[6].

Noise sources should be acoustically controlled to levels below 80 dB(A) to diminish workers' exposure[7]. However, as an immediate and low-cost measure, individual control prevails, diminishing their exposure by wearing personal protective equipment (PPE). Joy et al. (2007)[8] found a trend towards lower noise levels in the mining industry (1987 to 2004) associated with more rigorous enforcement by occupational-health public authorities. Tikka et al. (2017)[9] pointed out the need for long-term follow-up studies to verify the effects of PPE use in reducing ONIHL when integrated with a well-implemented HCP.

The effectiveness of HCP has little scientific evidence. This may be due to the complexity of assessment research to this end, which is essential to evaluate the effects of the program[10]. Recent studies demonstrate an interest in this topic. Frederiksen et al. (2001-2010)[11] associated reduced industrial noise levels and increased PPE use with lower ONIHL prevalence. A study by Rabinowitz et al. (2005-2014)[12] in 13 metallurgical plants of a single organization associated lower ONIHL prevalence with plants committed to the management and participation of health professionals in educative activities.

Hence, this study aimed at analyzing the impact of HCP on ONIHL prevalence, in a metallurgical plant.

METHODS

This study was approved by the Ethics Committee of Universidade Federal de Pernambuco, Brazil, under evaluation report number 3.824.458 and had the consent of the aforementioned company.

This case study[13] assessed the impact of HCP on ONIHL, analyzing the period from 2003 to 2018. Aspects of occupational noise exposure were also considered, encompassing the same period.

The study was carried out at a large metallurgical transformation plant in the state of Pernambuco, certified in the Quality Management and Environmental Management Systems, active for more than 3 decades. Its degree of risk is classified as level four, and continuous noise is the predominant occupational risk agent. There has been low employee turnover in the period, and HCP has been ongoing for over 2 decades.

The inclusion criteria were as follows: workers who underwent audiometric examinations in 2018 and had been participating in the HCP for at least 15 years. Employees with a history of occupational exposure to ototoxic chemical products[6] and/or vibration[14,15] at any moment throughout the study period, regardless of whether the exposure level was above regulatory tolerance limits, were excluded. Thus, the study comprised 152 workers. The population had 98.7% males. Their mean age at the beginning of the series was 33.6 years (SD = 5.9) and, at its end, 48.4 years (SD = 5.8).

ONIHL indicators were the outcome variables. The year of occurrence, mean noise exposure level, and HCP practices aimed at ONIHL prevention were independent variables. The prevalence of employees with changes suggestive of ONIHL and the stability of changes suggestive of ONIHL were the indicators measured with audiometric examinations. Annual prevalence was calculated by dividing the number of workers with changes suggestive of ONIHL by the studied population and multiplying the result by 100. Annual stability was measured by the proportion of progression stages (degrees) of the changes suggestive of ONIHL, taking the number of employees with changes per degree of progression, divided by the total number of employees with changes suggestive of ONIHL in the population, multiplied by 100.

Data on HCP practices aimed at ONIHL prevention were collected from documents and interviews with a questionnaire (Appendix 1). Audiometric data were collected from a database.

To collect data on HCP practices aimed at ONIHL prevention, HCP-participant employees were identified and contacted via phone call to present the study and verify whether they were interested in participating. Then, they signed an informed consent form, and the questionnaire was administered to each one in different moments, simultaneously verifying the corresponding documents.

The questionnaire was developed based on the researcher's experience and the HCP analysis and judgment matrix developed by Silva et al.[16], adapted to this study. It has 46 closed-ended questions covering the same items for the years 2003 to 2018 and room for observations (Appendix 1). The interviewees had different HCP participation times in the study period. The occupational physician worked in the HCP throughout the study period; the health safety engineer worked in it from 2008 to 2018, and the speech-language-hearing therapist, from 2016 to 2018.

HCP practices were assessed in six dimensions, namely: (1) Occupational health policies, (2) Collective control measures, (3) Educative measures, (4) Employee exposure assessment, (5) Personal protective equipment, and (6) Auditory surveillance.

The items were assessed by measuring the annual index of practices used per dimension. Each item was assessed based on the workers' responses and documentary evidence. In case of divergence between responses, the one backed by documentary evidence prevailed. A single response, either positive or negative, was considered per item. The index of practices per dimension was calculated by dividing the number of practices used in that dimension by the total number of items in the dimension, multiplied by 100, year by year.

A total of 2,350 audiometric examination records of the 152 workers were collected from the database for analysis – one examination per worker, per year (the last one made) was evaluated, averaging 15.5 examinations per employee. The audiometric records contained data on both auditory thresholds and occupational exposure.

The workers were categorized into three levels according to their mean noise exposure level, as recommended by the Ministry of Labor[17]: a) **level 1**, whose exposure is above or equal to permissible limits (85 dB[A]); b) **level 2**, whose exposure is above or equal to the action level and below permissible limits (80 to 84.9 dB [A]); c) **level 3**, whose exposure is below the action level (< 80 dB[A]).

In audiometric assessments, auditory thresholds were classified as recommended by the Ministry of Labor[4]: a) **within acceptable limits** for pure-tone thresholds lower than or equal to 25 dB(HL) at 0.5, 1, 2, 3, 4, 6, and 8 kHz; b) **changes suggestive of ONIHL** for increases in pure-tone thresholds, with unilateral or bilateral sensorineural symmetrical hearing loss with a characteristic notch and thresholds above 25 dB (HL) at 3, 4, and/or 6 kHz, and above the ones at 0.5, 1, 2, and 8 kHz; c) **changes not suggestive of ONIHL** for increases in pure-tone thresholds that are not characterized as suggestive of ONIHL.

In stability assessment, the progression stages of audiometric changes suggestive of ONIHL were classified according to Leite (1996)[18]: a) **degree I**, verified in the initial phase of ONIHL, whose change is limited to 3, 4, and/or 6 kHz, with one or more auditory thresholds above 25 dB (HL) and arithmetic mean of these thresholds not above 45 dB (HL); b) **degree II,** whose changes in auditory thresholds are still limited to 3, 4, and/or 6 kHz, but the arithmetic mean of these thresholds ranges from 46 to 55 dB (HL); c) **degree III**, whose arithmetic mean auditory thresholds at 3, 4, and 6 kHz are above 55 dB (HL), either associated or not with threshold change at 2 kHz – which, if changed, is not above 40 dB (HL); d) **degree IV**, whose arithmetic mean auditory thresholds at 3, 4, and 6 kHz are above or equal to 55 dB (HL) and the auditory threshold at 2 kHz is simultaneously above 40 dB (HL).

Descriptive statistics were used for data analysis. Absolute (n) and relative (%) frequencies were calculated, as well as measures of central tendency (arithmetic means and medians) and dispersion (standard deviations).

RESULTS

In the study period, the six dimensions had high HCP practice indices (Figure 1).

An 89% index was found for occupational health policies from 2003 to 2008, and 78% from 2009 to 2018. The items that negatively contributed to the calculations were the absence of occupational health and safety ISO certification throughout the period and the lack of a committee comprising employees and a technical team to develop HCP measures between 2009 and 2018.

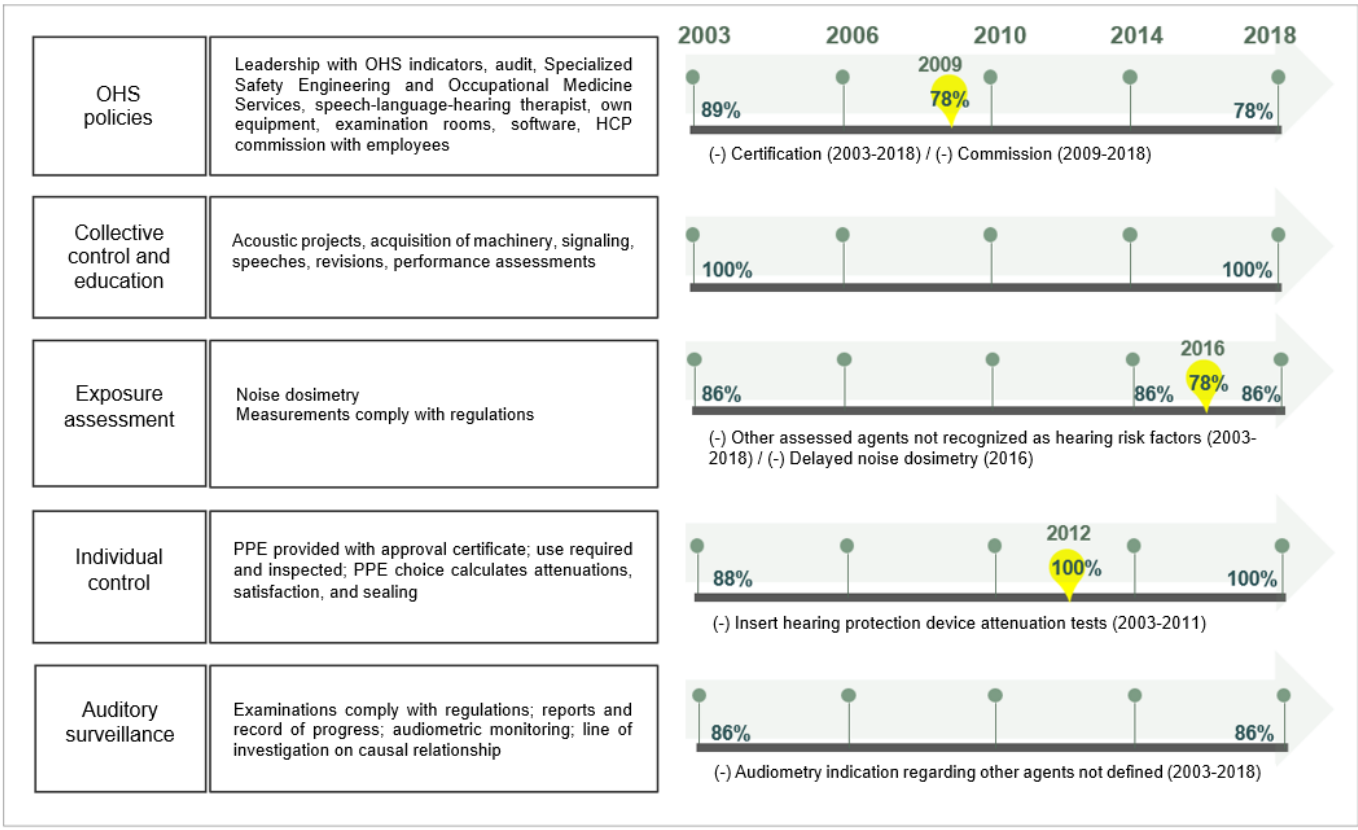
In both collective control measures and educative measures, a 100% index was found from 2003 to 2018.

An 86% index was found for employee exposure assessment from 2003 to 2018, except for 2016, whose index was 78%. The items that negatively contributed

to the calculations were the absence of records that other hearing risk agents were recognized throughout the period and the delayed noise dosimetry schedule in 2016.

In individual control (PPE use), an 88% index was found from 2003 to 2011 and 100%, from 2012 to 2018. The item that negatively contributed to the calculations was the absence of individual attenuation tests of PPE from 2003 to 2011.

In auditory surveillance, an 86% index was found from 2003 to 2018. The items that negatively contributed to the calculations were the absence, in both the Occupational Health Medical Control Program and HCP throughout the study period, of records of audiometry recommendations for those exposed to other hearing risk agents.



Source: The authors.
Captions: OHS = Occupational health and safety. PPE = Personal protective equipment.

Figure 1. Indicators of practices aimed at preventing occupational noise-induced hearing loss in a metallurgical plant in PE, Brazil

The 2003-2018 exposure assessment of the study population showed a 20.4% reduction in the proportion of exposed workers in level 1, with a simultaneous 19.1% increase in this proportion in level 2 and a 1.3% increase in level 3 (Figure 2).

Period 2003-2018																			
Indicators	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Mean**	**Median**	**SD**
Proportion of noise-exposed workers (%)																			
Level 1	50.7	52.6	52.0	51.3	32.9	32.9	36.8	38.8	38.8	39.5	42.8	40.8	42.8	40.8	42.1	30.3	41.6	40.8	6.8
Level 2	36.8	34.9	33.5	36.8	53.3	53.3	49.3	48.8	44.1	44.7	40.8	39.5	38.2	40.1	42.8	55.9	43.3	41.8	6.7
Level 3	12.5	12.5	12.5	11.8	13.8	13.8	13.8	13.2	17.1	15.8	16.4	19.7	19.1	19.1	15.1	13.8	15.0	13.8	2.5

Source: The authors.
Captions: SD = standard deviation. Level 1 = ≥ 85 dBA. Level 2 = 80 to 84.9 dBA. Level 3 = < 80 dBA.

Figure 2. Profile of the population per noise exposure level in a metallurgical plant in PE, Brazil (n = 152)

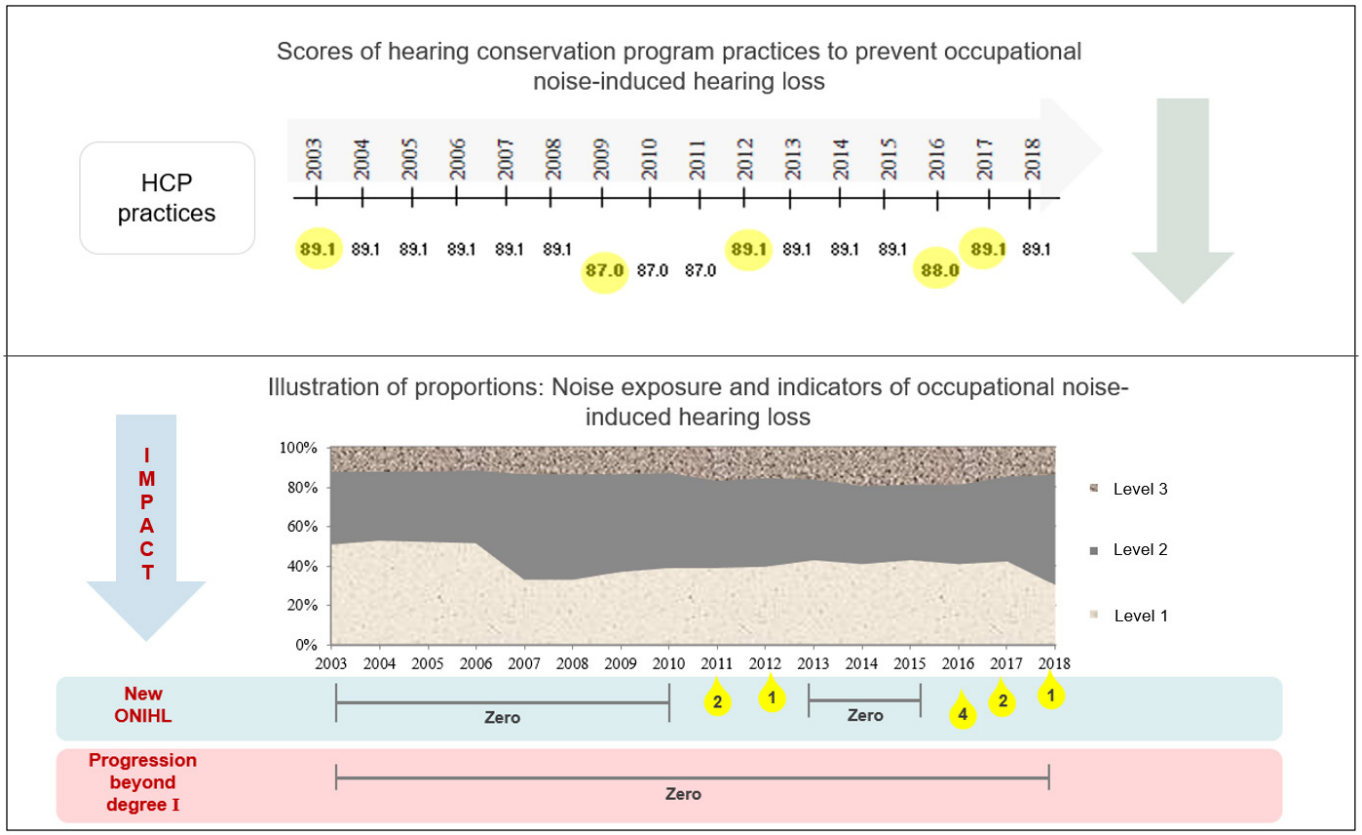
The audiometric profile of the population in the study period showed an 11.8% and 18.4% initial and final prevalence, respectively, of audiometric changes suggestive of degree-I ONIHL. The proportion of workers with acceptable auditory thresholds decreased by 15.8% from 2003 to 2018, with a simultaneous 6.6% increase in the proportion of auditory threshold changes suggestive of degree-I ONIHL (Figure 3).

Period 2003-2018																			
Indicators	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Mean**	**Median**	**SD**
Audiometric Results (%)																			
WAL	79.6	79.6	80.9	80.9	80.9	78.9	77.0	76.3	75.0	73.7	73.7	71.7	71.1	67.8	66.4	63.8	74.8	75.7	5.3
ONIHL (degree I)	11.8	11.8	10.5	10.5	9.2	10.5	11.8	11.8	13.2	13.8	13.8	13.8	13.8	16.4	17.8	18.4	13.1	12.5	2.6
Non-ONIHL	8.6	8.6	8.6	8.6	9.9	10.5	11.2	11.8	11.8	12.5	12.5	14.5	15.1	15.8	15.8	17.8	12.1	11.8	2.9

Source: The authors.
Captions: SD = standard deviation. WAL = auditory thresholds within acceptable limits. ONIHL = auditory thresholds with changes suggestive of occupational noise-induced hearing loss. Non-ONHIL = auditory thresholds with changes not suggestive of occupational noise-induced hearing loss.

Figure 3. Audiometric profile of the population in a metallurgical plant in PE, Brazil (n = 152)

HCP practices and ONIHL indicators reveal high and constant percentages in the assessment of HCP practices aimed at ONIHL prevention. Also, ONIHL indicators were low, suggesting an inversely proportional relationship between them (Figure 4).



Source: The authors.
Captions: ONIHL = auditory thresholds with changes suggestive of occupational noise-induced hearing loss. Level 1 = ≥ 85 dB(A). Level 2 = 80 to 84.9 dB(A). Level 3 = < 80 dB(A).

Figure 4. Hearing conservation program versus occupational noise-induced hearing loss in a metallurgical plant in PE, Brazil (n = 152)

DISCUSSION

HCP assessment showed a high overall compliance index in the items, whose practices help reduce the risk of ONIHL. Findings in Brazilian studies indicate different practices. A study by Dantas et al.[19] interviewed 40 health professionals (20 speech-language-hearing therapists and 20 occupational physicians) in Manaus and verified they were essentially focused on meeting law requirements to avoid lawsuits in the labor court. Gonçalves et al.[20] interviewed human resource managers in 26 companies in Paraná; 46.2% of them reported having HCP, although the measures were limited to performing audiometry and providing PPE. For HCP to have satisfactory results, the companies and health professionals must make the workplace conducive to safety behaviors, with a key person[21] coordinating measures in involved sectors and focusing on results, according to planned goals.

Different measures are found worldwide in ONIHL studies[22], perhaps due to differences in or absence of regulatory requirements. Such differences include having (or not) correction factors for age and analyzed ONIHL progress stage. Like most Brazilian studies, the measure used in this one followed the national regulations, assessing ONIHL from its initial stage, without age-correction factors.

The 18.4% prevalence of changes suggestive of ONIHL and 6.6% incidence found at the end of this study series were lower than the 41.43% prevalence and 30.7% incidence found by Gonçalves et al.[23]. Their study sample had 741 employees of four factories in the state of São Paulo, HCP participants with a mean

16.7-year exposure time. The existing difference may be related to the high HCP practice index to prevent ONIHL in the study company.

Concerning stability of ONIHL cases, despite the long exposure time, changes suggestive of ONIHL remained in degree I (initial ONIHL stage). In other words, they did not evolve as expected in natural ONIHL progression[4,24], whose most advanced stage would take place after 15-year noise exposure. Such stability also makes evident the successful ONIHL-prevention HCP practices.

The overall reduction in the proportion of workers in this study exposed to noise above 85 dB(A) between 2003 and 2018 may be a result of collective measures implemented in the period. Nevertheless, despite the continuous collective reduction measures, better results were obtained in 2006 and 2007, with a gradual and slight increase in the proportion of workers exposed to noise above 85 dB(A) from 2008 to 2017. Also, between 2016 and 2018, the proportion of workers exposed to noise below 80 dB(A) decreased, consequently increasing exposure in the company. The increase in ONIHL cases from 2016 to 2018 may be associated with the increase in occupational noise exposure. Morata et al.[10] researched factories that had implemented noise-reduction projects – an increasingly addressed, recognized, and encouraged topic in some countries, such as Taiwan, Australia, and the USA. Primary preventive measures eliminating noise are enough to eliminate the risk of ONIHL.

The low incidence of cases suggestive of ONIHL and the maintenance of changes suggestive of degree-I ONIHL in the study period point to a relationship with HCP practices in this company. This is highlighted by the motivating organizational environment, 20% reduction in workers exposed to sound pressure levels above tolerance limits, continuous educative measures, systematic noise-exposure monitoring, conscious hearing protection use, and technical team integration.

Limitations that stand out in this study include the lack of interviews with the workers, memory bias (though minimized by document verification), and the absence of conclusions on causal relationships regarding cases suggestive of ONIHL.

CONCLUSION

The evidence points to a positive impact of HCP on ONIHL control in this metallurgical plant, in the period studied, resulting from an organizational policy and practices continuously aiming at ONIHL prevention.

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APPENDIX 1. ASSESSMENT OF PRACTICES CARRIED OUT BY THE COMPANY TO PREVENT HEARING LOSS

Responses year by year: "Y" (Yes) or "N" (No) or "U" (Unknown).																	
I	**Occupational Health Policies**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
1	Does the company have an occupational safety certificate?																
2	Is compliance with safety rules one of its administrators' performance indicators?																
3	If employees do not comply with occupational safety rules, does the company take disciplinary measures?																
4	Are employees' occupational medical examinations part of its administrators' performance indicators?																
5	Does the extent of the Specialized Safety Engineering and Occupational Medicine Services comply with current regulations?																
6	Does the company have a Hearing Conservation Program (HCP)?																
7	Does the company have routine HCP audits?																
8	Does the company involve employees other than the Specialized Safety Engineering and Occupational Medicine Service team in HCP development?																
II	**Collective control measures**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
9	Does the company make provision in its budget for acoustic projects to reduce noise?																
10	Has the company undertaken acoustic projects to reduce noise?																
11	Does the company evaluate equipment sound power when acquiring production machinery?																
III	**Educative measures**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
12	Does the company provide training to newly hired employees on occupational risks, cautions, and safety rules?																
13	Does the company take educative measures on occupational risks, cautions, and safety rules at least once a year?																
14	Is training revised once a year?																
15	Does the company assess the participants' performance in training?																
IV	**Worker exposure assessment**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
16	Does the company have job descriptions for the employees?																
17	In the environmental assessment, does the company consider the physical risk due to noise?																
18	In the environmental assessment, does the company consider the physical risk due to full-body vibration?																
19	In the environmental assessment, does the company consider the chemical risk?																
20	In the environmental assessment, does the company consider the ototoxic chemical risk?																
21	Does the company regularly make quantitative assessments of the physical risk due to noise?																
22	Does the company perform noise dosimetry in employees exposed to physical risk due to noise?																
23	Does the company inform employees of their noise dosimetry results?																
V	**Personal protective equipment – PPE**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
24	Are employees provided with PPE according to recognized risks?																
25	Does the company have signs indicating the required PPE in risk places?																
26	Does the company acquire certified PPE approved by regulating agencies?																
27	Does the company evaluate the level of noise reduction of hearing protection devices?																
28	Does the company verify hearing protection fitting?																

29	Does the company assess the employees' satisfaction with the hearing protection provided?																
30	Does the company periodically replace hearing protection devices?																
31	Does the company require and inspect hearing protection use?																
32	Does the company make individual attenuation tests of the hearing protection devices?																
VI	**Auditory surveillance**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
33	Does the company recommend audiometry to employees at recognized noise risk?																
34	Does the company recommend audiometry to employees at recognized ototoxic risk?																
35	Does the company recommend audiometry to employees at recognized full-body vibration risk?																
VI	**Auditory surveillance**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
36	Does the company plan audiometry in the periodicity required by current regulations?																
37	Does the company perform 100% of planned audiometry?																
38	Does the company perform 100% of audiometry in its facilities?																
39	Does the company perform sequential audiometry, month by month, throughout the year?																
40	Does the company perform audiometry according to the technical parameters required by current regulations?																
41	Does the company monitor the progression of auditory thresholds according to current regulations?																
42	Does the company conduct audiometric monitoring simultaneously with audiometry?																
43	Does the company individually instruct employees regarding changes in their audiometry?																
44	Does the company make reports analyzing the employees' hearing stability?																
45	Has the company defined a line of multidisciplinary investigation to determine causal relationships?																
46	Does the company conduct multidisciplinary investigations to determine causal relationships in progressions?																

Date Researcher (name/signature) Interviewee (position/name/signature)

Room for observations

Clarifications about the questions.

Attention! Responses may differ from one year to another.

I. Occupational health policies

Occupational health and safety certificate: Process through which an independent entity assesses, based on audits, whether the company meets the standards of hazard identification systems and elimination or attenuation of risks from identified hazards.

Performance indicators: Goal achievement parameters according to the established by the organization.

Disciplinary measures: Admonition, suspension, or fair dismissal of employees who break the company's rules.

Occupational medical examination: Examination upon which an occupational health certificate is emitted.

Specialized Safety Engineering and Occupational Medicine Services: Team of professionals defined by Brazilian regulatory norm NR4, determined according to the degree of risk of the company's main activity and its number of employees.

II. Collective control measures

Acoustic projects: Every equipment change or replacement that physically changes the source or transmission of high sound pressure levels, reducing the sound pressure levels to which workers are exposed – e.g., installing silencers, enclosing machinery, reducing vibration in wall panels and structures with sound-absorbing material.

Performance indicators: Goal achievement parameters according to the established by the organization.

Administrative control: Measures taken to change the way of working or operating machines and reduce exposure – e.g., alternating employees in places where there are high sound pressure levels, operating certain equipment in shifts or hours with the least people present, assessing equipment sound power when acquiring it.

III. Educative measures

Educative measures: Measures taken to educate and motivate employees with training programs, courses, debates, commissions, and events. These measures must ensure that the workers at least understand HCP issues, namely: health effects of exposure to high sound pressure levels, notions of environmental assessments, collective protection measures, notions of hearing and audiometric examination; practical training to put on, use, care for, and replace hearing protection devices.

IV. Worker exposure assessment

Job description: Detailed description of the activities a worker performs in the company.

Recognition of noise risk: Stage of the work setting qualitative assessment in which activities that pose noise risk capable of hurting employees according to regulatory norms NR9 and NR15 are identified, recognized, and characterized.

Recognition of full-body vibration risk: Stage of the work setting qualitative assessment in which activities that pose full-body vibration risk capable of hurting employees according to regulatory norms NR9 and NR15 are identified, recognized, and characterized.

Recognition of chemical risk: Stage of the work setting qualitative assessment in which activities that pose chemical risk capable of hurting employees according to regulatory norms NR9 and NR15 are identified, recognized, and characterized.

Recognition of ototoxic chemical risk: Stage of the work setting qualitative assessment in which activities that pose ototoxic chemical risk capable of hurting employees according to FUNDACENTRO are identified, recognized, and characterized.

Quantitative assessment of noise: Measurement, according to regulatory norms NR9 and NHO 01, of the noise intensity to which employees are exposed.

Noise dosimetry: Quantitative assessment of the employees' exposure to high sound pressure levels, using an integrating personal-use meter, whose results are shown in percentage of sound energy in relation to the maximum daily limit of sound energy.

V. Personal protective equipment – PPE

Personal protective equipment (PPE): Every personal-use device or product worn by workers to protect them from risks that may threaten their health and safety at work. The PPE referred to in this paper is that used for hearing protection.

Certificate of PPE approval: Certificate emitted by corresponding national agencies authorizing PPE to be sold and used.

Noise reduction level of hearing protection devices: Sound energy attenuation value hearing protections provide to their wearers, shown in dB in its certificate of approval.

Verification of PPE fitting: Qualitative personal verification of how well a hearing protection device fits its wearer, specifying whether the PPE provides adequate sound isolation to its wearer.

PPE personal attenuation test: Quantitative sound isolation testing method that estimates the personal attenuation level for hearing protection wearers, shown in dB SPL.

VI. Auditory surveillance

Auditory surveillance: Measures used along with audiometry; medical history; referrals to specialized services; investigation n cases of significant threshold changes; multidisciplinary meetings; operational and technical reports.

Pure-tone threshold audiometry: Examination that assesses audibility threshold – i.e., the lowest intensity capable of causing a sound sensation in a person due to sound stimuli in different tones, shown in dB HL.

Recommendation for audiometry: Medical recommendation to perform pure-tone audiometry as part of the Occupational Health Medical Control Program, based on results of the company's risk environmental assessment.

Audiometry planning: Audiometry schedule, following the recommendations of the Occupational Health Medical Control Program.

Audiometry: Audiometry examinations performed according to medical recommendations, considering the minimum recommended periodicity and legal technical parameters established by regulation norm NR7

Referral to specialized services: Referral of employees for assessment, treatment, and evaluation report by an otorhinolaryngologist.

Audiometric monitoring: Analysis of auditory stability with follow-up of auditory threshold progression in sequential audiometry in relation to reference audiometry. The parameters used in this paper are based on lesion progression – i.e., the progression of the degree of auditory acuity impairment.

Causal relationship: Logical cause-and-effect relationship with an established link between occupational activities and occupational diseases.