LEX LOCALIS-JOURNAL OF LOCAL SELF-GOVERNMENT
ISSN:1581-5374 E-ISSN:1855-363X
VOL. 23, NO. S6(2025)

HEARING IMPAIRMENT DUE TO OCCUPATIONAL NOISE EXPOSURE IN WORKERS IN A PLASTICS INDUSTRY, 2024

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Abstract
The human ear can detect sounds ranging from 0 to 120 dB; however, prolonged exposure to higher levels may cause severe hearing damage and affect the nervous system. Therefore, it is essential to implement preventive measures in industrial settings, where occupational diseases related to noise continue to rise due to the lack of effective corrective actions. This study aimed to evaluate auditory capacity impairment in workers exposed to occupational noise in a plastics industry during 2024. A quantitative methodology with a descriptive, correlational, and cross-sectional approach was used. The sampling was non-probabilistic and purposive. Audiometric evaluations and sound pressure level measurements were conducted on a total of 64 workers. Results showed that 85.5% of the sample were male workers exposed to noise, with a small percentage presenting mild to moderate hearing loss. In the extrusion, trimming, and production control areas, workers maintained normal hearing; however, in the printing, sealing, and grinding areas, a significant percentage exhibited mild to moderate hearing loss. The sealing and trimming areas complied with noise level regulations, whereas the printing and extrusion areas presented hazardous sound levels for auditory health. In conclusion, prolonged exposure to noise levels above permissible limits was significantly associated with hearing deterioration in workers ($r = -0.266$; $p = 0.034$), confirming noise as a cumulative occupational risk factor.

Keywords: Hearing impairment, noise exposure, occupational noise, occupational health, plastics industry.

Introduction

Exposure to occupational noise is a significant global public health challenge. Projections by the World Health Organization (WHO) indicate that by 2050, one in four people could experience some degree of hearing loss (WHO, 2025). In the industrial context, this problem becomes especially critical, since constant exposure to high-intensity sounds can cause irreversible hearing damage and other health conditions (Briones et al., 2023). To minimize these risks, it is essential to implement preventive measures, such as the proper use of hearing protection equipment, limiting noise exposure and designing ergonomic workspaces.

This study is essential to identify the risk factors present in the work environment and develop effective strategies to protect workers' hearing health. It also seeks to promote training and awareness of the dangers associated with noise, which will contribute to improving the physical and mental well-being of employees, boosting productivity and reducing costs related to occupational diseases (International Labour Organization, 2025).

Continuous exposure to high levels of noise generates work stress and negatively affects productivity, forcing employees to extend their working hours and compromise their rest to fulfill their responsibilities, due to difficulties concentrating (Cárdenas, 2024). This overload can cause physical and mental fatigue, increase anxiety, and affect emotional well-being, impacting operational efficiency (Cabrera et al., 2022). In the long term, these conditions can lead to occupational health problems and increase staff turnover, affecting the stability and profitability of organizations (Suárez et al., 2020).

Noise, as a physical agent, has the potential to cause hearing damage and affect the emotional state of workers (Talavera et al., 2019). In plastics industries, employers often fail to conduct proper assessments of noise levels, simply supplying earplugs without measuring the actual impact of the machines. In addition, some employees do not use hearing protection equipment correctly, citing difficulties hearing faults in the machines or unfamiliarity with their use.

In Ecuador, the manufacturing sector, particularly the plastics industry faces a high risk of hearing loss due to constant exposure to noise generated by noisy equipment in processes such as extrusion and sealing. The lack of preventive measures, such as measuring noise levels and the proper use of hearing protection, exacerbates this problem, resulting in noise-induced hearing loss, a common and long-lasting disorder in occupational health (UNIR, 2025).

Globally, it is estimated that 16% of disabling hearing loss in workers is attributed to occupational noise, with variations between 7% and 21% depending on the country (Marcano et al., 2023). In the United States, this condition is one of the most prevalent, affecting millions of workers exposed to dangerous levels of noise and ototoxic substances (Pan American Health Organization, 2021).

This study focuses on evaluating the impact on hearing capacity caused by exposure to occupational noise in workers in a plastics industry during the year 2024. To achieve this general objective, the following specific objectives were proposed: to identify critical areas of noise exposure within the industry; to determine the level of hearing impairment in exposed workers; to evaluate compliance with current regulations on noise levels in the different work areas; and, finally, to establish preventive recommendations to mitigate this occupational risk and protect the hearing health of the staff.

Methodology

The present study adopted a quantitative approach, with a descriptive, correlational and cross-sectional scope, whose objective was to evaluate the impact on hearing capacity in workers exposed to industrial noise. The results of 64 audiometry tests and sound pressure levels measured in employees of a plastics industry located in the city of Quito during the year 2024 were analyzed. The study population consisted of plant operating workers, distributed in various production areas, such as extrusion, printing, trimming, sealing, milling, and production control. Initially, 76 employees were included, aged between 18 and 65 years, all of whom were directly exposed to industrial noise levels above the permissible limits during their working day (five days a week).

The sampling was non-probabilistic of a propositional type, which limits the generalization of the results to the entire population of the sector, due to the lack of randomness and statistical representativeness. The final sample was made up of 64 workers who met the established inclusion criteria. The data used in this study were obtained by means of audiometry previously performed by specialized personnel, as well as by measurements of the sound pressure level expressed in

decibels (dB), using a calibrated sound level meter. In addition, on-site visits were made to the different work areas to directly observe the noise exposure conditions.

Regarding ethical considerations, the study was approved by the UTN Research Ethics Committee and written informed consent was obtained from all participants, guaranteeing at all times the confidentiality, anonymity and responsible use of the data collected, in accordance with the principles of the Declaration of Helsinki. The hypotheses put forward for this study were the following:

H1: Exposure to industrial noise has a negative impact on the hearing ability of workers in the plastics industry.

H0: Exposure to industrial noise does not have a significant impact on the hearing capacity of workers in the plastics industry.

The tabulation of the results was performed using the statistical software IBM SPSS STATISTICS (Version 25). To evaluate the relationship between the time of exposure to noise and hearing impairment, Pearson's correlation test was applied, establishing a confidence level of 95% and a significance level of 5% to demonstrate the hypothesis.

This analysis made it possible to determine whether there was a statistically significant association between the noise levels to which the workers were exposed and the results of the audiometry tests performed. The instruments used to measure the noise variable were Cirrus class 2 sound level meters, in accordance with the guidelines established in the Ecuadorian Technical Standard NTE INEN-ISO 9612.

In addition, information on hearing capacity (audiometry) and noise levels (sonometry) was considered in accordance with Ministerial Agreement No. 196 of 2024 of the Ministry of Labor, which establishes a maximum level of 85 decibels (dB):

Table 1. *Relationship between Noise Levels (Measured with Sound Level Meter) and Hearing Ability (Evaluated with Audiometry) According to Ministerial Agreement No. 196-2014 of the Ministry of Labor of Ecuador*

Aspect	Description	Regulations	Value/Reference
Noise exposure	Evaluation of noise levels in the workplace using sonometry	Ministry of Labor 196/2024	Maximum level: 85 dB
Hearing	Evaluation of workers' hearing health through audiometry	Ministry of Labor 196/2024	Hearing loss detection from 85 dB
Noise Level	Sound pressure level measurement in the workplace	Sound Level Meter	Must not exceed 85 dB
Exposure limit	Maximum duration of exposure to continuous noise at levels of 85 dB	Ministry of Labor 196/2024	8 hours a day at 85 dB
Induced hearing loss	Risk of permanent hearing damage from prolonged exposure to noise	Ministry of Labor 196/2024	Risk of hearing loss from constant exposure to 85 dB

Fountain: (Ministerio del Trabajo de Ecuador, 2024)

A comprehensive search was conducted in scientific databases, such as PubMed, BMJ Journals, Medline, Dialnet, and Google Scholar. The search included scientific articles, systematic reviews, and doctoral theses related to the effects of industrial noise on hearing, in both English

and Spanish, to contextualize the findings and ensure the quality of the information used in the study.

Results and discussion

Demographic Characterization of the Sample

From the demographic point of view, it is observed that 14.4% of the sample corresponds to the female group, who did not participate in the research due to their exclusion because they were not exposed to significant occupational noise. In contrast, 85.5% (**n=64)** of the sample corresponds to the male group, of which one was excluded for the same reasons as the female staff; this gender distribution is consistent with the segmentation of tasks observed in this type of industry. This phenomenon is common in industrial settings, where men often perform roles in areas of increased noise exposure.

Hearing Impairment by Age Groups

Taking into account studies such as that of Wu et al. (2021), which suggest that with similar exposures and ages, physiological differences could influence greater susceptibility in men to noise-related hearing loss, audiometry was analyzed that revealed a tendency to hearing deterioration with advancing age (Figure 1). In the 20-30 age group, 30% (95% CI: 25%-35%) of the study population had normal hearing, while only 2% (95%CI: 1%-3%) had mild hearing loss. We can then determine that in this specific group a lower prevalence of hearing impairment was found, which would suggest an adequate state of hearing health at the beginning of their working life in the industry.

In the 31-50 age group, the proportion of normal hearing remains relatively high at 48% (95% CI: 43%-53%); despite this, an increase in the incidence of hearing loss was observed, thus obtaining that: 3% (95% CI: 2%-4%) of workers in this age range suffered from mild hearing loss and 2% (95% CI: 1%-3%) had moderate hearing loss, which is an indication of hearing impairment that could be related to the accumulation of exposure to occupational noise.

In the 51 to 65 age group, the greatest hearing impairment was evidenced, since only 13% (95% CI: 10%-16%) maintained normal hearing, 2% (95% CI: 1%-3%) had mild hearing loss, and another 2% (95%CI: 1%-3%) moderate hearing loss. The significant decrease in normal hearing in this group is consistent with the natural process of presbycusis and is accelerated by chronic exposure to noise within their workplace, as highlighted by Gannouni et al. (2024)

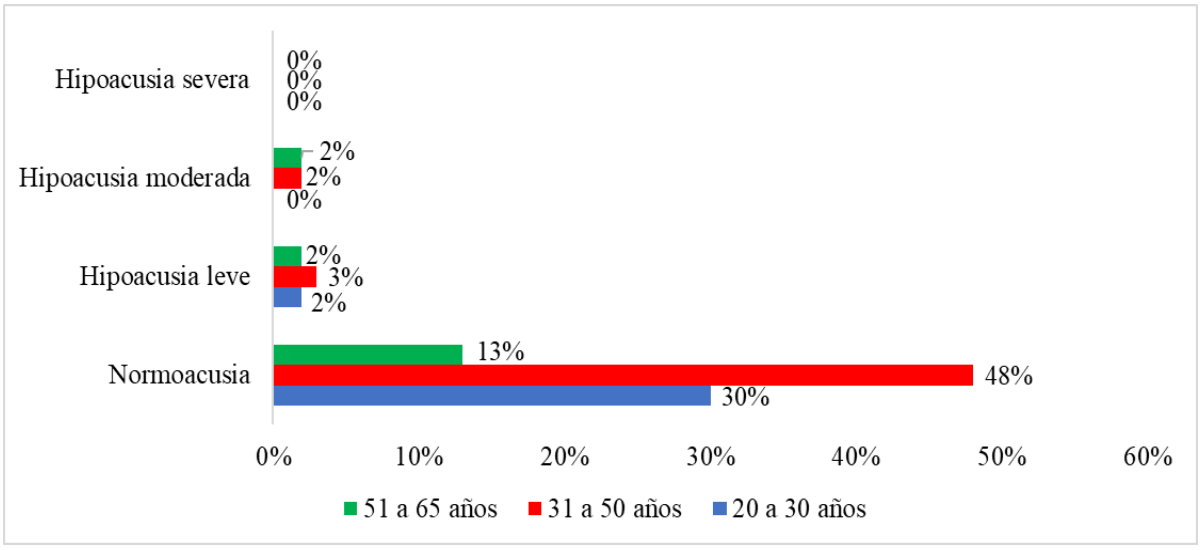

Figure 1. *Audiometry results by age group.*
Source: Own elaboration (2025). in original language: Spanish

Analysis of Hearing Impairment by Job

Audiometric evaluation by work area (Figure 2) revealed notable differences in the prevalence of hearing loss. The extrusion, trimming and production control areas showed no cases of hearing loss, suggesting controlled noise levels or lower exposure in these areas.

In contrast, the impression area had a higher incidence of auditory impairment. Of 15 workers, 80% (95% CI: 72%-88%) had normal hearing, while 13% (95% CI: 8%-18%) had mild hearing loss and 7% (95% CI: 3%-11%) had moderate hearing loss.

In the sealing area, of 30 workers, the majority (93%, 95% CI: 89%-97%) maintained normal hearing. Only 3.3% (95% CI: 1%-5%) had mild hearing loss and another 3.3% (95% CI: 1%-5%) had moderate hearing loss, indicating a minor impact in this section.

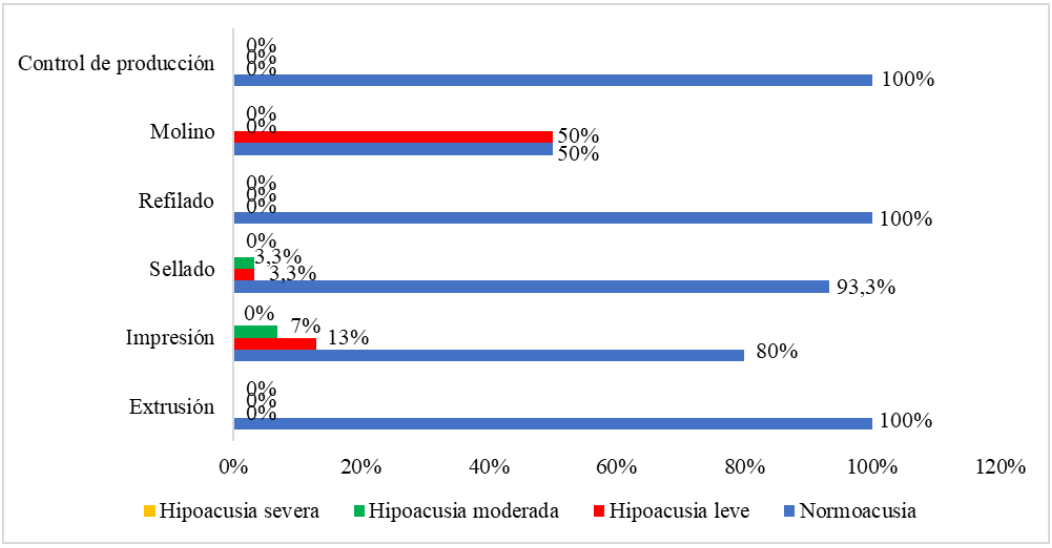

Figure 2. *Audiometry results by workstation.*
Source: Authors' elaboration (2025). in original language: Spanish

The mill area showed the greatest affectation, with 100% (n=2, 95% CI: 100%-100%) of its two workers presenting some degree of hearing loss. Specifically, 50% (95% CI: 0%-100%) had mild hearing loss and the other 50% (95% CI: 0%-100%) had moderate hearing loss. Although the sample is small, this finding is highly significant and suggests critical noise exposure at this stall. A worker in the printing area with moderate hearing loss, not belonging to a high-risk age group, highlights that exposure to occupational noise is a determining factor, regardless of age.

Noise Level Assessment and Regulatory Compliance

The sonometry measurements (Table 2) showed that most areas of the industry exceed the exposure limits allowed by Ecuadorian regulations (Ministerial Agreement 196, Annex 3), the ACGIH and NIOSH (85 dB for 8 hours of exposure).

Table 2. *Results of sonometry measurements.*

Workstation	Weighted Daily Noise	Permissible limit	Hours of exposure	Complies/Not Complies
Extrusion	89,6	85	8	Not compliant
Impression	90,3	85	8	Not Compliant
Sealed	84,3	85	8	Meets
Trimming	81,6	85	8	Meets
Mill	88,1	85	8	Not compliant
Production Control	85,5	85	8	Not compliant

Source: Authors' elaboration (2025).

The print area was the most critical, with an equivalent sound level of 90.3 dB(A). It was followed by extrusion (89.6 dB(A)), mill (88.1 dB(A)) and production control (85.5 dB(A)). All these areas do not comply with the regulations. The average standard deviation of noise measurements in non-compliant areas was ±2.5 dB(A).

On the other hand, the sealing (84.3 dB(A)) and trimming (81.6 dB(A)) areas do comply with the established limit, which correlates with the lower incidence of hearing loss observed in their workers. This pattern reinforces the importance of noise management in the workplace as a crucial factor for workers' hearing health. Noroña and Laica (2022) have also reported that exposures above 85 dB(A) significantly increase the risk of irreversible hearing loss

Correlation between Exposure Time and Hearing Impairment

The Pearson correlation test (Table 3) was performed with a confidence level of 95% and a significance level of 5% ($p < 0.05$) to evaluate the hypothesis that exposure to occupational noise affects hearing ability.

Table 3. *Pearson's correlation test, with a confidence level of 95% and a significance level of 5% to prove the hypothesis*

Correlations

		Time of occupational exposure	Audiometry 2024
Time of occupational exposure	**Pearson correlation**	1	-,266*
	Sig. (bilateral)		,034
	N	64	64
Audiometry 2024	**Pearson correlation**	-,266*	1
	Sig. (bilateral)	,034	
	N	64	64

***. The correlation is significant at the 0.05 level (bilateral).**

Source: Authors' elaboration (2025).

The analysis yielded a Pearson correlation coefficient (r) of -0.266, with a p-value of 0.034. Given that the p-value (0.034) is lower than the significance level (0.05), the null hypothesis is rejected, indicating that there is a statistically significant correlation between the time of occupational exposure and hearing impairment in workers in this plastics industry.

The negative correlation of low intensity (r = -0.266) suggests that, the longer the time of occupational exposure, there is a slight but significant trend towards greater hearing impairment. In other words, although it is not a strong linear relationship, the exposure time factor contributes to hearing impairment. The statistical significance (p=0.034), with a 95% confidence interval, allows us to affirm with high probability that this relationship is not the product of chance. This is consistent with the cumulative nature of noise-induced hearing loss, where even prolonged exposure to non-extreme levels can lead to disturbances

The results of sonometry measurements carried out in 2024 in the production area revealed noise levels that exceed the limits set by regulations such as ACGIH and NIOSH, which recommend a maximum of 85 dB to prevent hearing damage. This reinforces concerns about constant exposure to industrial noise as a risk factor in hearing impairment.

General Discussion of Findings

The impairment of hearing capacity due to exposure to occupational noise is a growing public health problem, and the results of this study confirm this in the context of the plastics industry evaluated. Industrialization and lack of awareness of the risks of noise aggravate its impact on health.

It was observed that hearing loss tends to increase with age and years of occupational exposure, being more noticeable after the age of 31, suggesting a greater risk after more than six years of work in this industry. Noise levels in key positions such as extrusion, printing, mill and production control consistently exceed the permissible limit of 85 dB, posing an imminent risk to workers' hearing health.

Comparing with other studies, while Acebedo (2021) reports an average age of 38.5 years in women and 37.7 in men in the manufacturing industry, the current findings show that the predominant group in the plastics industry evaluated is between 31 and 50 years old (53%), followed by the 20 to 30 year old group (31%). This distribution highlights that a significant portion of the workforce is in an age range where susceptibility to PAIR may increase with cumulative exposure.

The discrepancy in regulatory compliance in different areas of the plant underscores the urgency of implementing engineering and administrative controls. This includes isolation of sound

sources, improved machinery design, staff turnover in noisy areas, and mandatory use of certified hearing protectors. A robust Occupational Health and Safety Management System (OH&S-MS), with a well-defined hearing conservation program, is indispensable to mitigate risks and protect workers' hearing in the long term.

Conclusions

The findings of the present study confirm that there is a significant relationship between prolonged exposure to noise levels above permissible limits and progressive deterioration of hearing capacity in workers in the plastics industry. The printing, extrusion and mill areas showed the most critical levels of sound exposure, being associated with cases of mild to moderate hearing loss, particularly in workers over 30 years of age, although it was also evident in young personnel. These conditions reflect a clear hearing vulnerability in the working population and position industrial noise as a cumulative occupational risk.

In response to this problem, it is recommended to immediately implement a comprehensive hearing conservation plan within the SG-SST, which includes: (1) mandatory annual audiometric evaluations; (2) staff turnover in high-exposure areas; (3) quarterly preventive maintenance of noisy machinery; (4) provision and mandatory use of certified hearing protectors; (5) continuous training on noise risks; and (6) construction of physical barriers or soundproof booths in critical areas. In addition, it is suggested to establish an institutional policy of longitudinal monitoring with occupational health indicators, and the incorporation of these results as part of the company's epidemiological surveillance system, with six-monthly monitoring and adjustment schedules.

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