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Audiometric Database of Academic Musicians in Uruguay

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Abstract

Background: *This paper presents the results of an interdisciplinary study at the Universidad de la República (Uruguay), in which hearing loss is assessed in a group of academic musicians, including lyric singers, choristers, and orchestral musicians.* **Methods:** *Audiometric records from 137 academic musicians were analyzed. The Average Hearing Loss (PAM) methodology, based on Lafon and Duclos combined with the ISO 1999:2013 Standard, was used to convert all the registers to the hearing loss at the age of 35, which were then organized into a permanence curve and compared with reference curves from the ISO 1999:2013 Standard.* **Results and Conclusion:** *The results presented here are estimated to represent more than 27 % of the total population of adult academic musicians nationwide. The findings suggest that academic musicians in Uruguay are at a higher risk of noise-induced hearing loss than the general population in the ISO 1999:2013 Standard.*

1. Introduction

Artists often form a community that lacks adequate occupational health attention [1]. For example, in Uruguay, artists only receive occupational accident and illness insurance if they are employees. This requires institutions to contract the services of the Banco de Seguros del Estado [2]. In the case of professional musicians, there is a common belief that they shouldn't suffer hearing loss due to their profession since they "enjoy what they do." However, this concern has gained traction recently, driven by demands from artists' collectives and more nuanced interpretations of their needs.

In response, a group of teachers from the Universidad de la República (Uruguay) in health, art, and science-technology initiated an interdisciplinary project to quantitatively analyse the hearing health of academic musicians, specifically lyric singers and orchestral musicians. Funded by the University's Interdisciplinary Space, this project has been ongoing for over four years, including workshops, audiometries, and interviews by the Speech and Hearing and Occupational Health teams, processed with an

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epidemiological approach. A methodology combining the Average Hearing Loss (PAM) from Lafon and Duclos and the ISO 1999 Standard guidelines was utilized, which has been in use in Uruguay since 1993 for comparing occupational exposure among worker groups, crucial for assessing regional hearing loss.

We studied three musician groups: the choristers of the National Choir of SODRE, the musicians of the Montevideo Symphonic Band, and the students from the Singing Department of the Faculty of Arts. Members of the Orquesta Sinfónica del SODRE and the Orquesta Filarmónica de Montevideo, each with about 95 performers, also participated in various activities. Occupational hearing damage can develop gradually through prolonged noise exposure or acutely from sudden loud noise, resulting in hyperacusis, which limits conversational understanding [6]. Tinnitus is another symptom indicating noise damage.

It's important to note that noise alone isn't the sole cause of hearing damage. Ototoxic chemicals can also harm the auditory system temporarily or permanently. These include antibiotics like gentamicin, diuretics like furosemide, and NSAIDs like naproxen [7]. Damage begins in the inner ear's organ of Corti, particularly the cochlea's hair cells that detect high-frequency sounds around 4000 Hz. This initial damage often doesn't affect the perception of the human voice, meaning individuals may not notice a hearing loss initially. The resulting damage is a bilateral, symmetrical, and irreversible sensorineural hearing loss. Additional noise effects include sleep disturbances, impaired concentration, anxiety, and stress, alongside impacts on cardiovascular, respiratory, and digestive systems and hormone secretion like cortisol and adrenaline. These effects vary based on individual tolerance. According to the WHO, hearing loss occurs with a threshold increase of at least 20 dB. It can be classified as mild, moderate, severe, or profound, with disabling loss defined as greater than 35 dB in the better-hearing ear [9]. Noise is a primary risk factor in work environments. In Uruguay, Decree 143/012 outlines measures to prevent harmful health consequences from sound pressure exposure, setting an 80 dBA noise limit for an 8-hour workday to ensure preventive measures and regular audiometric surveillance above this level. This work aims to share the method and results of the research project that enabled our team to obtain a reference audiometric database of Uruguayan academic musicians. Since this is a restricted data set, we adapted the methodology for determining the Acoustic Hazard proposed in [5] for its processing. To calculate it, the following steps were employed for the case presented here:

1. Calculate the hearing loss of each participant by applying the criterion (2000+4000)/2). This criterion refers to the arithmetic average of the hearing loss measured at 2000 Hz and 4000 Hz when a pure tones audiogram is performed. It is the PAM defined in [3]. In this case, the average hearing loss of both ears is 2000 and 4000 KHz.
2. Read the value of the mean hearing loss PAM on the abacus of Lafon and Duclos [3] .
3. Construct the permanence curve of the obtained PAM values.
4. Select an audiometric basis for comparison. In this case, we will work with Base A, presented in the ISO 1999:2013 Standard, and with Base B, corresponding to a reference population also presented in the same standard [4]. Base B, corresponding to the US population, was adopted since the other options offered in ISO 1999:2013 correspond to Sweden and Norway [4]; it was understood that the similarity in lifestyle with the latter two countries would be even less than with the United States.

The ISO 1999 Standard, since its 1990 version – now superseded by the 2013 version – defines two types of audiometric databases: the type A database, which is a theoretical database representing the minimum expected hearing loss for different percentiles of a population of a certain age and sex, otologically screened, without previous exposure to environmental noise or ototoxic drugs. It is interpreted as the minimum expected hearing loss. Base A can be calculated mathematically following the methodology provided by [4], assuming that the distribution of hearing loss at each frequency and gender and age range follows a distribution given by two branches of Gaussian bells sharing their vertex. Base B, on the other hand, is empirically derived (it does not admit theoretical calculation) and represents the hearing loss resulting from the lifestyle of a particular society, i.e., it considers both presbycusis (natural aging process) and socioacusis [4].

Hearing loss was calculated using the criterion [(2000+4000)/2] for each audiometric record. According to [11], this is the most preventive criterion among those commonly applied due to the high weighting (50%) given to the loss at 4000 Hz, one of the frequencies at which hearing loss sets in. The losses obtained in this way were averaged, and the average additive loss for both ears was followed. Each of the values obtained was taken to the loss to be expected at the age of 35 years, applying the abacus in Figure 4 [3]. This is the value designated as PAM. Then, the curves of permanence for each of the databases and for our database were constructed and compared to determine the outcomes of this study.

2. Methods

A retrospective observational study was carried out with a primary data source. For this purpose, an instrumental environmental assessment was carried out, and medical and occupational medical records and audiometric studies were performed on the study population. Subsequently, the information collected was processed by means of electronic spreadsheets for subsequent analysis. The audiometric tests were performed by a speech audiology team in a soundproofed environment according to the ISO Standard 8253-1, using an Audiometer MAICO MA-41, and the results were recorded in audiograms.

2.1. Fieldwork

In all cases, the activities began and closed with a workshop. The first workshop aimed to present the project, introduce the subject, explain the activities, ensure participants signed informed consent forms, and address any questions. In the closing workshop, results were shared with participants, who could schedule personal interviews with the Health team for individualized feedback. The Philharmonic Orchestra opted out of the feedback workshop for scheduling reasons.

Before the workshops, a guideline was developed to collect information during participant interviews, covering anamnesis aspects and specific factors related to singing or instrumental performance, such as vocal register, instrument played, artistic activity type and frequency, and regular use of amplification.

Participants made individual appointments with an occupational physician and a speech therapist to fill out the anamnesis form and undergo otoscopy and pure tone audiometry. They were informed to rest their hearing for 12 hours prior to audiometry and avoid optic infections. Importantly, audiometries aimed to assess the threshold of perception in different frequency bands rather than stopping at audiometric zero [5, 11-12].

For singers, a diagnosis of vocal status was conducted, including anamnesis, body assessment based on vocal use, aerodynamic efficiency evaluation, perceptual assessment (GRBASI scale), subjective assessment (S-VHI), and acoustic analysis via Praat Software. Individual results were shared with each participant in a second workshop, along with a summary of joint findings from collected data.

2.2. Characterization of the Study Population

In the survey, 137 subjects were enrolled: 59 women and 78 men; 62 singers (choristers, lyric singers, singing students) and 75 musicians from instrumental ensembles (orchestras and symphonic bands). The institutions from which the participating musicians come are Instituto de Música (EUM) of the Facultad de Artes (teachers and singing students, choristers); Banda Sinfónica Municipal de Montevideo (BSM); Coro Nacional del SODRE (CNS); Orquesta Sinfónica del SODRE (OSSODRE); Orquesta Filarmónica de Montevideo (OFM).

The total population of academic musicians in Uruguay—those engaged in “conservatory” music, such as members of instrumental ensembles, professional solo singers, and other soloists—constitutes a small community. Professional orchestras and choirs are mainly in Montevideo, comprising fewer than

400 individuals. Including other professional musicians and students from the Escuela Universitaria de Música at Facultad de Artes, the estimated total is about 500. This community is roughly 65% male and 35% female, with instrumentalists proportionately similar and singers at about 40% male and 60% female.

To assess sound exposure, the sound pressure level maps of the National Choir and the Symphonic Band of Montevideo are shown in Figures 1 and 2. The lowest recorded levels are at 85 dBA, while the legal occupational sound pressure level is 80 dBA in Uruguay. Notably, the Symphonic Band has implemented a "street" between brass and woodwind instruments to reduce exposure levels for woodwind musicians.

Notably, only one musician's job is assessed, not the entirety of the worker's sound exposure, which is a weakness of the study that the researchers recognize.

3. Results

The PAM permanence curve for the whole database was constructed, and then the results were obtained separately for men and women, singers, and orchestral musicians. In each case, the resulting curves were overlaid with the corresponding curves obtained for each sex and 35 years of age from the data in Bases A and B. The audiometry results are presented as a percentage of the population of each gender, together with the reference

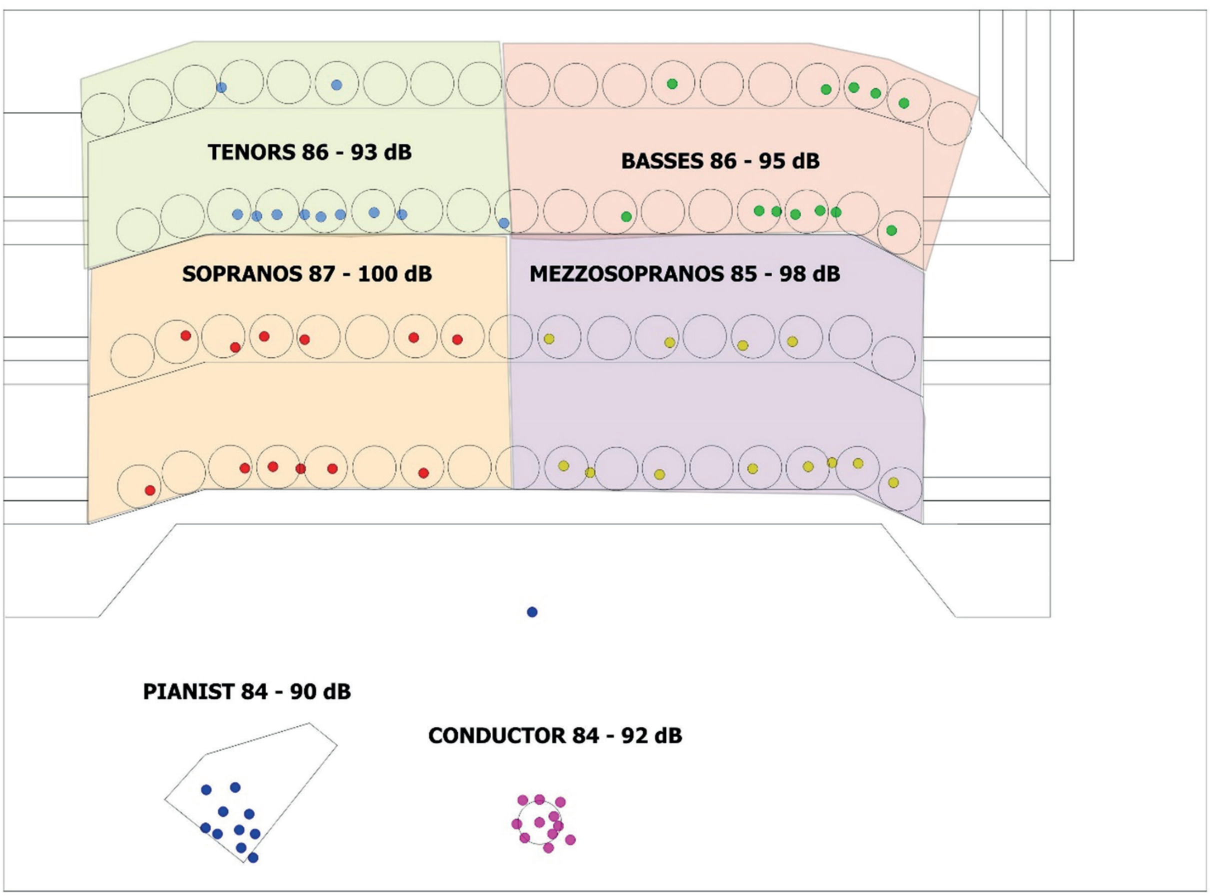

Figure 1. Map of Sound Pressure Levels of the National Choir.

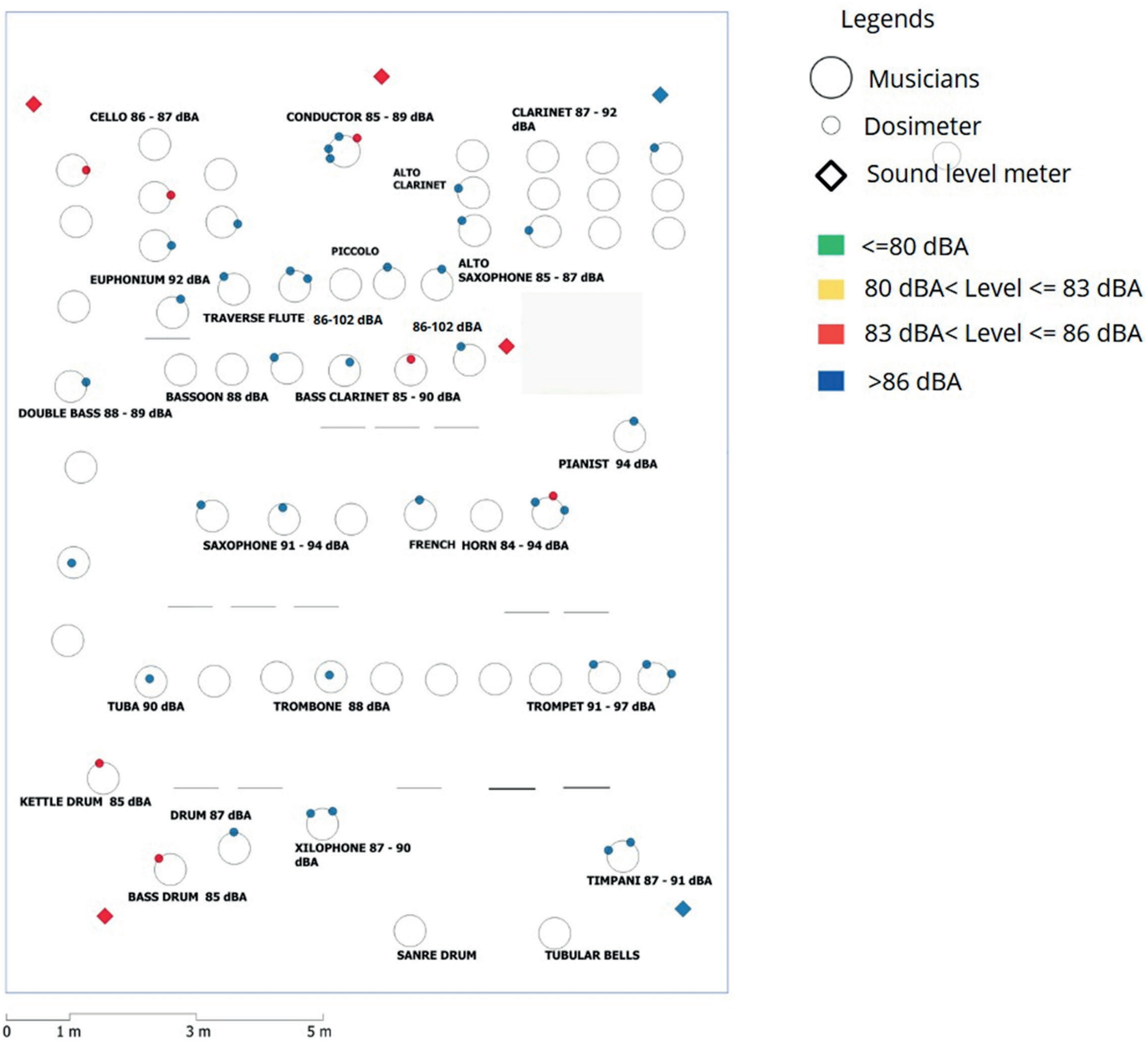

Figure 2. Map of Sound Pressure Levels of the Symphonic Band of Montevideo.

curves corresponding to Bases A and B from [4]. Only the results of the study population in the range of 10 % to 90 % are plotted to follow the range in which ISO A and B bases are defined [4]; as in the reference bases, the PAM values of 10 % by 10 % are used.

Figure 3 represents the minimum expected loss measured as PAM (that is, at 35 years of age) for different percentiles of the study population, considered as a whole, men only (PAM Male) and women only (PAM Female). The results for the total population (PAM) have a precision of 1.4 dB at 95% confidence and the results by gender have a precision of 2.0 dB for men (PAM Male) and 1.6 dB for women (PAM Female).

Figure 4 presents the results for singers (EUM and CNS). Figure 5 presents the results for instrumental ensemble musicians (BSM, OSSODRE, OFM). The singers' and musicians' curves have respective accuracies of 1.6 dB and 1.7 dB. The Singers

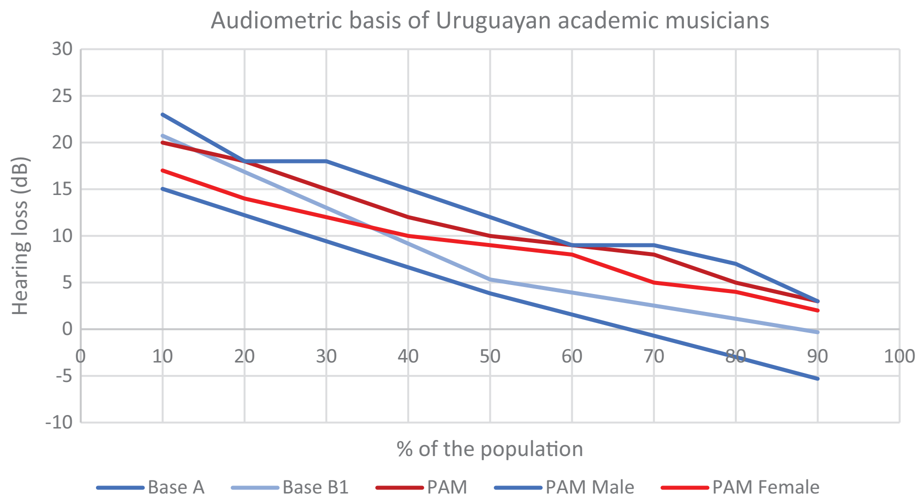

Figure 3. Audiometric basis of Uruguayan academic musicians: average PAM of both ears. Total base (mixed PAM), men only (PAM M), and women only (PAM F).

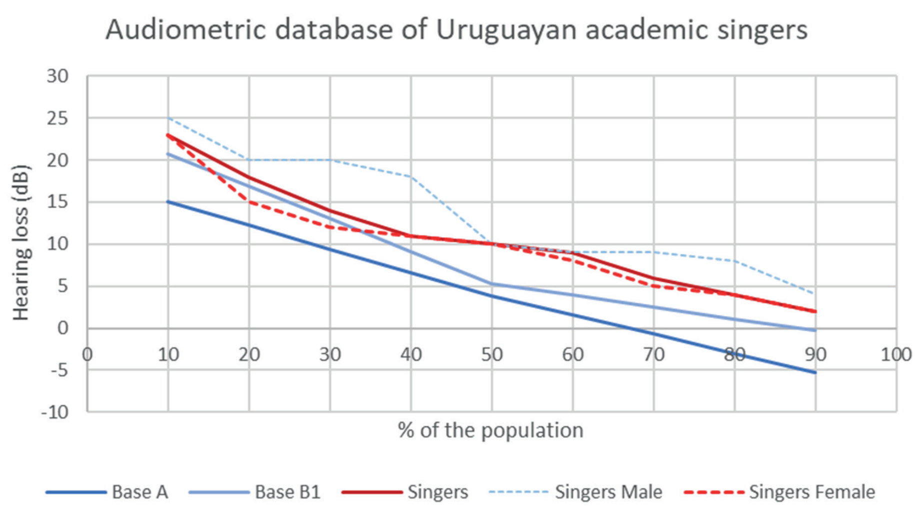

Figure 4. Audiometric basis of Uruguayan singers and choristers: average MAP of both ears. Total base (singers), only men (Male singers), and only women (Female singers).

F and Musicians M curves have 1.5 dB and 1.7 dB errors. The Singers M and Musicians F curves correspond to less than 20 cases each, so their values have not been included in the tables.

4. Discussion

Hearing loss in the population of academic musicians of both genders has a marked tendency to exceed the values of Bases A and B [13]. The whole base and the male base exceed the expected loss curves given by both bases by almost their entire length, while the predicted hearing loss in females is, for the lowest 60% loss, higher than that proposed by Base B for the North American population [14]. Several recent studies reporting similar findings have been reviewed [15].

For singers, the expected loss in the curve exceeds the curve for academic musicians in general. The scheduled hearing loss for male singers seems

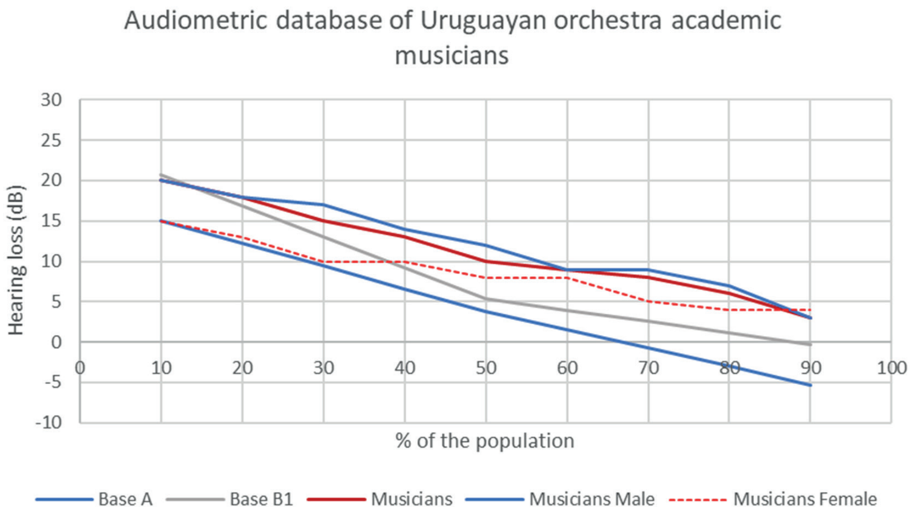

Figure 5. Audiometric basis of Uruguayan musicians in orchestral ensembles: average PAM of both ears. Total base (musicians), only men (Male musicians) and only women (Female musicians).

considerably higher than for female singers, but the number of available cases confers a high error and, thus, low reliability. In the case of orchestral musicians, the expected hearing loss for all musicians is similar to that expected for men but higher than expected for women [15].

In the case of women, the error obtained is 2 dB, at the limit of what has been considered admissible, and for this reason, the curve values have not been noted. The loss of the orchestral musicians can be associated with that of the men in that group and that of the singers with that of the women. The total population of musicians shows higher loss than the unexposed populations, and it is higher for men than women.

Through this study, the exposure of musicians to an environmental risk factor such as noise is made visible, with a potential risk of damaging hearing health. The problem is visible and allows us to work on preventive measures and raise awareness among musicians and those who direct this sector. On the other hand, it is an input for generating health policies in Occupational health.

5. Conclusion

The audiometric results are comparable with the workers' accounts and perceptions of noise in their work environment. Likewise, the decrease in hearing observed in the curves of the population under study, compared to the reference population, shows a real risk of damage to hearing health. Therefore, it is essential to be able to work on occupational health policies that encourage the promotion and prevention of hearing health in this group of workers, as well as in the rest of the risk factors to which they are exposed.

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Institutional Review Board Statement: Although the research involved paraclinical, non-invasive studies such as tonal audiometry, the subsequent analysis was based on anonymized data. For this, the participants were informed and signed an informed consent, which detailed the purpose of the study and the use of the data for research purposes. The audiometry results were delivered to each participant individually, respecting the confidentiality that a medical intervention implies.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

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Declaration of Interest: The authors declare no conflict of interest.

Author Contribution Statement: AEG, FT, GCl, BLB, SP, AP, LCR, US and BT contributed to the conception and design of the research, GCo, LDP and SP performed the audiometric tests, AEG, FT, GCl, BLB, AP, LCR, US and BT contributed to the analysis of the results, and AEG, FT, AP, US and BT contributed to the writing of the manuscript.

Declaration on the Use of AI: None.

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