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# AUDIOMETRIC PROFILE OF PROFESSIONAL MUSICIANS: SYSTEMATIC REVIEW

## *Perfil audiométrico de músicos profissionais: revisão sistemática*

## *Perfil audiometrico de músicos profesionales: revisión integrativa*

**Carina Moreno Dias Carneiro Muniz**
CEUMA University (*Universidade CEUMA - CEUMA*) - São Luis (MA) - Brazil

**Camila Malcher Teixeira Amorim**
CEUMA University (*Universidade CEUMA - CEUMA*) - São Luis (MA) - Brazil

**Ilana Mirian Almeida Felipe**
CEUMA University (*Universidade CEUMA - CEUMA*) - São Luis (MA) - Brazil

**Rosane da Silva Dias**
CEUMA University (*Universidade CEUMA - CEUMA*) - São Luis (MA) - Brazil

**ABSTRACT**

**Objective:** To know professional musicians' audiometric profile. M**ethods:** A systematic review of the literature was carried out in the online databases of CAPES Journals and Virtual Health Library (VHL) using the descriptors "music", "noise-induced hearing loss", "tinnitus" and "audiometry". In the PubMed database, we used the MESH headings: "music", "audiometry" and "hearing loss", using Boolean term "and". We included observational studies in English, Spanish and Portuguese that assessed the occurrence and factors related to hearing loss in professional musicians dating from 2006 to 2016. The articles were peer-selected. **Results:** The searching strategy resulted in 819 studies, of which only 13 met the eligibility criteria. Of all the musicians analyzed by the thirteen studies included in this review, 31,24% presented noise-induced hearing loss. **Conclusion:** The present review verified a consensus among the findings of the studies analyzed regarding the fact that musicians present noise-induced hearing loss, with tinnitus being the most frequent symptom, which indicates the existence of hearing alterations among these professionals.

**Descriptors**: Music; Audiometry; Hearing Loss, Noise-Induced; Noise, Occupational.

***RESUMO***

***Objetivo:*** *Conhecer o perfil audiológico de músicos com dedicação profissional.* ***Métodos:*** *Conduziu-se uma revisão sistemática da literatura nas bases eletrônicas Periódicos CAPES e Biblioteca Virtual em Saúde (BVS) utilizando os descritores "música", "perda auditiva induzida pelo ruído", "zumbido" e "audiometria". Na base PubMed, utilizaram-se os termos MESH: "music", "audiometry" e "hearing loss", utilizando os operadores booleanos "e" e "and". Incluíram-se estudos observacionais, em inglês, espanhol e português, que avaliaram a ocorrência e os fatores relacionados à perda auditiva em músicos profissionais, datados de 2006 a 2016. A seleção dos artigos aconteceu por pares.* ***Resultados:*** *A estratégia de busca resultou em 819 estudos, dos quais apenas 13 preencheram os critérios de elegibilidade. Dos músicos avaliados pelos treze estudos incluídos, 31,24% apresentaram perda auditiva induzida pelo ruído.* ***Conclusão****: Por meio dessa revisão foi possível identificar que os achados da literatura são consensuais quanto à detecção de que músicos apresentam perda auditiva induzida por ruído, sendo o zumbido o sintoma auditivo mais frequente, o que é indicativo que existe alteração na audição desses profissionais.*

***Descritores:*** *Música; Audiometria; Perda Auditiva Provocada por Ruído; Ruído Ocupacional.*



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***RESUMEN***

***Objetivo:*** *Conocer el perfil audiológico de músicos con dedicación profesional.* ***Métodos:*** *Se realizó una revisión sistemática de la literatura en las bases de datos electrónicas Periódicos CAPES y Biblioteca Virtual en Salud (BVS) utilizando los descriptores "música", "pérdida auditiva provocada por el ruido", "zumbido" y "audiometría". En la base PubMed se utilizaron los términos MESH: "music", "audiometry" y "hearing loss" con los operadores booleanos "e" y "and". Se incluyeron los estudios observacionales, en inglés, español y portugués que evaluaron la ocurrencia y los factores relacionados con la pérdida auditiva de músicos profesionales entre 2006 y 2016. La selección de los artículos se dio por pares.* ***Resultados:*** *La estrategia de búsqueda resultó en 819 estudios de los cuales solamente 13 cumplieron los criterios de elegibilidad. De entre los músicos evaluados en los trece estudios incluidos, el 31,24% presentaron pérdida auditiva provocada por el ruido.* ***Conclusión****: A partir de esa revisión ha sido posible identificar que los hallazgos de la literatura presentan un consenso respecto la detección de que los músicos presentan pérdida auditiva provocada por el ruido siendo el zumbido el síntoma auditivo más frecuente lo que es una indicación de que hay alteración de la audición de estos profesionales.*

***Descriptores:*** *Música; Audiometría; Pérdida Auditiva Provocada por Ruido; Ruido en el Ambiente de Trabajo.*

## INTRODUCTION

People are born with normal hearing, but a significant number of them have hearing loss. Some of the most common causes are congenital, such as rubella and syphilis, and acquired, which affects people who are continually exposed to excessive noise, especially occupational noise, which has been shown to have characteristics of irreversible hearing loss[1,2].

According to the World Health Organization (WHO), more than 5% of the world's population, i.e., about 360 million people, have disabling hearing loss (328 million adults and 32 million children). Most of these people live in underdeveloped countries[3]. It is estimated that 1.1% of the Brazilian population is self-declared disabled, with permanent difficulty to hear[4].

The number of cases of hearing loss in people exposed to occupational noise is increasing. In this regard, the work environment has been generating high noise levels and the lack of adequate protection is not uncommon[5]. Musicians are at a high risk of hearing damage because they are regularly exposed to high levels of sound pressure because the source of these sounds is usually very close to their ears. In addition, musicians are reluctant to use of ear plugs[6]. A study conducted with Rock musicians in Norway found 37.8% of audiometric notch exams compatible with noise-induced hearing loss (NIHL)[7].

It should be noted that musicians do not have any legal support for health and safety at work, which may refer to a misconception about the idea that musicians are not workers or that if music is pleasant it will does not pose any risks to health[8]. In this regard, studies have reported occupational losses among musicians, including hearing loss[9,10].

Studies on the impacts of noise on musicians' hearing or that point out, in a grounded manner, the factors that affect it are scarce. Therefore, considering that hearing is an important resource for these professionals and their quality of life, studying the effects of noise on musicians' hearing is relevant. Given that, the present review aimed to know professional musicians' audiometric profile.

## METHODS

In order to accomplish the proposed objective, a systematic review of the literature was carried out based on the guidelines established by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses – PRISMA[11]. In the data collection process, the research question was formulated using the PICO strategy, with "P" for patients or population, "I" for intervention or area of interest, "C" for comparison and "O" for outcomes. Thus: P: Professional musicians; I: exposure to music in a professional routine; C: comparative group/control; O: diagnostic criteria for hearing loss using audiometry or otoacoustic emissions.

Given that, the following research question was formulated: considering that exposure to noise in high sound pressure levels can lead to noise-induced hearing loss, what is the audiological profile of professional musicians? Noise-induced hearing loss (NIHL) or audiometric notch exams compatible with NIHL were considered hearing loss. The search for articles took place from June 2 to 20, 2016, in the following online databases: MEDLINE (via PubMed), Capes Journals and Virtual Health Library (VHL).

Observational studies from 2006 on published in English, Portuguese and Spanish were included. Review articles, case studies or studies that were associated with preexisting diseases, genetic alterations, syndromes, auditory neuropathy and middle ear pathologies were excluded.

The search strategy used the following health descriptors (DeCs): “music”, “noise-induced hearing loss”, “tinnitus” and “audiometry” in Capes Journals and in VHL databases. In the PubMed database, MESH headings and their correspondents were used: “music”, “audiometry” and “hearing loss”. The keywords were combined in in each database using the Boolean operators “and” and “*e*”.

In addition to the language of publication, the presence of the descriptors in the title or abstract was used as a filter in the article search strategy. After the articles were selected, bibliographical references were reviewed in order to select other studies that were not identified in the initial search.

Articles whose title and/or abstract exhibited the aim of studying hearing loss in musicians were considered eligible. The identified studies were selected by two independent reviewers according to title and abstract content. The articles that met the established criteria were included in the systematic review. Disagreements between the reviewers were resolved by consensus through the reading of the full study.

Tables were used to present the main results of the selected articles, information regarding the authors, year of publication, country, sample size and description and type of auditory examination (auditory tests) with the purpose of assisting in the visualization of the data in the results section. As a bias control strategy, authors were contacted via e-mail to consult on the existence of other studies that have not yet been published.

The evaluation of the methodological quality of the articles selected was carried out according to the criteria established in the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines. This instrument consists of 22 items related to information that should be present in the title, abstract, introduction, methodology, results and discussion of articles. The STROBE Initiative was developed by researchers in the fields of epidemiology, statistics and scientific methodology and aims to disseminate the principles that should guide the description of observational studies. The studies were evaluated using the classification “+”, “-” and “?” for, respectively, the presence of data, absence of data or incomplete data on the criterion studied.

## RESULTS

The article search strategy yielded 819 articles published from 2006 to 2016. After reading the titles, analyzing the abstracts and applying the eligibility criteria, 13 articles were included in the systematic review. The number of articles found in each database is depicted in Figure 1.

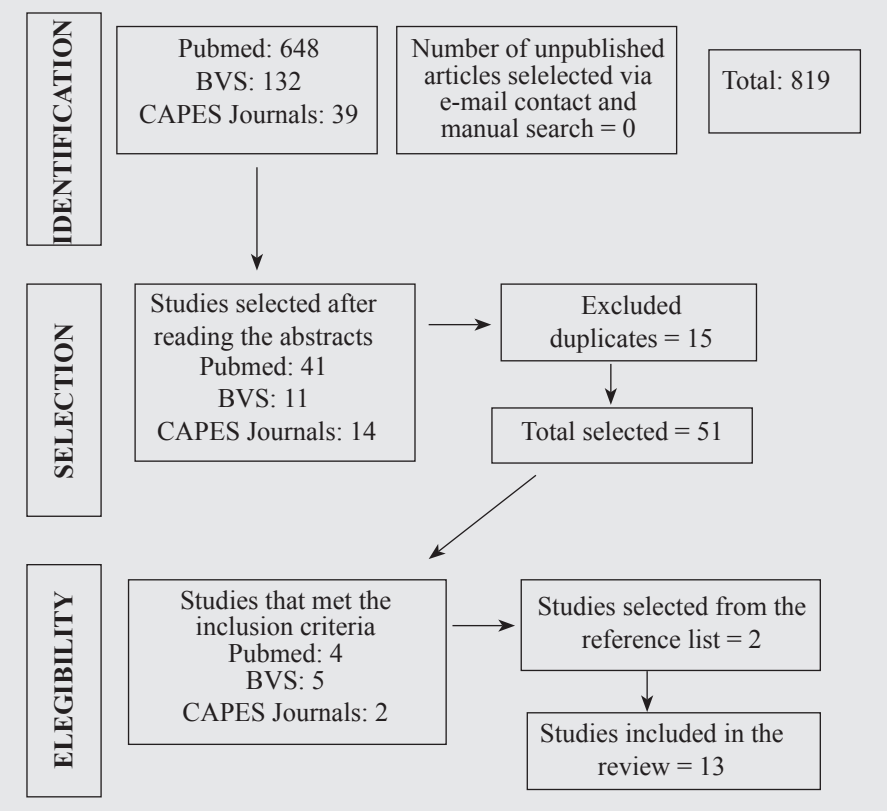


Figure 1: Flow chart describing the selection of the articles included in the systematic review.

Chart I shows the data on the characteristics of the studies regarding author, year and country of publication, musical field, sample size and age range of the sample. Most studied analyzed adults of both sexes aged 16 to 69 years. Two studies analyzed only men[12,13]. The studies were carried out in different countries: 64.28% in Brazil and the others in European countries (Norway, Sweden, Poland, England, Denmark and Finland). The sample size of the studies was heterogeneous and ranged 10 to 111 participants. The age range of the sample was not informed in 3 studies[14-16] and one of them indicated only the mean age of the participants[17]. As for the musical field, 14.28% were carried out with pop rock/rock musicians, 21.42% with orchestral musicians, 21.42% with military band musicians, 7.15% with samba school rhythmists, and 7.15% with guitarists. In all, 28.58% (five studies) of the studies did not report this data.

Chart I - Characteristics of the included studies: author, year and country of publication, musical field, sample size and age range.

| Author | Yer | Country | Musical field | Sample size (age range) |
|---|---|---|---|---|
| Stormer et al.[7] | 2015 | Norway | Rock musicians | 111 (16 and 52 years) |
| Gonçalves et al.[12] | 2007 | Brazil | Military band | 27 (22 and 50 years) |
| Samelli et al.[13] | 2012 | Brazil | Not specified | 16 (21 and 41 years) |
| Halevi-Katz et al.[14] | 2015 | Sweden | Pop/rock/jazz musicians | 44 (not informed) |
| Patil et al.[15] | 2013 | England | Army musicians | 84 (not informed) |
| Toppila et al.[16] | 2011 | Finland | Orchestral musicians | 67 (not informed) |
| Gonçalves et al.[17] | 2009 | Brazil | Military band of the Army | 50 (mean age of 34.9 years) |
| Maia et al.[18] | 2008 | Brazil | Not specified | 23 (21 and 38 years) |
| Martins et al.[19] | 2008 | Brazil | Not specified | 21 (18 to 59 years |
| Amorim et al.[20] | 2008 | Brazil | Not specified | 30 (18 and 37 years) |
| Monteiro et al.[21] | 2010 | Brazil | Samba school rhythmists | 10 (20 and 31 years) |
| Azevedo et al.[25] | 2012 | Brazil | Guitarists | 10 (17 to 69 years) |
| Dudarewicz et al.[33] | 2015 | Poland | Orchestral musicians | 18 (30-58 years) |

Chart II shows the prevalence of noise-induced hearing loss (NIHL) and the audiologic assessment method. In all, five studies did not report data on the prevalence of hearing loss. Of the studies that reported prevalence data[7,12,13,15,17,19-21], the sum of the participants totaled 349, of which 31.24% presented NIHL. Regarding the audiological tests used to assess hearing, pure tone audiometry appears in all studies, followed by immittance testing, 21.42% of distortion product otoacoustic emissions (DPOAE), 35.71% transient evoked otoacoustic emissions (TEOAE), and vocal audiometry.

Only six studies reported data on other auditory symptoms[7,17-19,21,25]. Tinnitus was the most frequent symptom and appeared in all studies. Other reported symptoms were difficulty understanding speech in noisy environment, intolerance to loud noises[17,18], ear fullness[18,19], dizziness[17,19] and otalgia[17].

Chart II - Data on the prevalence of NIHL and audiologic assessment method.

| Author | Prevalence of NIHL | Audiologic assessment |
|---|---|---|
| Stormer et al.[7] | 37.8% | Pure tone audiometry, immittance testing |
| Gonçalves et al.[12] | 18.5% | Pure tone audiometry, vocal audiometry, immittance testing and the threshold of pain |
| Samelli et al.[13] | 100% | Immittance testing and pure tone audiometry, TEOAE and ABR and cognitive potential |
| Halevi-Katz et al.[14] | NI | Audiometry |
| Patil et al.[15] | 14% | Pure tone and vocal audiometry |
| Toppila et al.[16] | NI | Pure tone audiometry |
| Gonçalves et al.[17] | 32% | Immittance testing and pure tone audiometry |
| Maia et al.[18] | NI | Pure tone audiometry, vocal audiometry, immittance testing, TEOAE and DPOAE |
| Martins et al.[19] | 42.9% | Audiometry |
| Amorim et al.[20] | 17% | Pure tone audiometry, immittance testing, TEOAE and DPOAE |
| Monteiro et al.[21] | 40% | Pure tone and vocal audiometry, immittance testing |
| Azevedo et al.[25] | NI | Pure tone audiometry, vocal audiometry, immittance testing, TEOAE and DPOAE |
| Dudarewicz et al.[33] | NI | TEOAE |

TEOAE: transient evoked otoacoustic emissions; DPOAE: distortion product otoacoustic emissions; ABR: auditory brainstem response; NI: not informed.

In order to recompile data on working life and the use of personal protective equipment (PPE), only five of the 13 studies presented data on the time spent on the job[12,17,19,20,25] and only four[12,17,20,25] presented data on duration of daily exposure to music. These data described in detail in Chart III. Only one study reported that 100% of the interviewees used ear protectors as PPE. The other studies did not provide these data[21].

Chart III - Data on the time spent on the job by musicians and the duration of daily exposure to music.

| Author | Time spent on the job (years) | Duration of daily exposure to music (hours) |
|---|---|---|
| Gonçalves et al.[12] | Between 5 and 26 years | Between 2 and 8 hours |
| Gonçalves et al.[17] | 48% between 11 and 20 years<br>26% between 21 and 30 years<br>26% 1 to 10 years | 44% from one to ten hours a week |
| Martins et al.[19] | 47.6% 6 to 10 years<br>23.80% 11 to 15 years<br>19% 16 to 20 years | Not informed |
| Amorim et al.[20] | 53.33% up to 10 years<br>46.66% more than 10 years | 43.3% from 1 to 4 hours<br>36.6% between 4 and 7 hours<br>20% between 7 and 10 hours |
| Azevedo et al.[25] | 9.5% more than 20 years | Mean of 15.2 hours a week |

Chart IV shows the evaluation of the methodological quality of the studies. Regarding this item, the criteria determined by STROBE were followed. No studies reported data on items 16, 17 and 22 (outcome estimates, extra analyses and funding sources, respectively). All studies responded incompletely to item 20 (interpretation of results). In addition, items 5, 7 and 11 were the most inconsistent.

Chart IV - Quality of the studies according to STROBE (*Strengthening the Reporting of Observational Studies in Epidemiology*) criteria.

| Authors/itens | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stormer et al.[7] | + | + | - | + | + | + | ? | + | + | + | ? | ? | + | + | + | - | - | + | + | ? | + | - |
| Gonçalves et al.[12] | - | - | - | - | ? | ? | ? | + | + | + | + | ? | + | + | + | - | - | + | - | ? | - | - |
| Samelli et al.[13] | + | + | - | + | ? | + | ? | + | ? | + | + | - | + | + | + | - | - | + | - | ? | + | - |
| Halevi-Katz et al.[14] | - | + | + | + | ? | + | ? | ? | ? | + | - | - | + | + | + | - | - | + | - | ? | + | - |
| Patil et al.[15] | - | + | - | + | ? | + | ? | + | - | + | + | - | + | + | + | - | - | + | - | ? | + | - |
| Toppila et al.[16] | - | - | ? | + | - | + | ? | + | ? | + | + | ? | + | + | + | - | - | + | - | ? | + | - |
| Gonçalves et al.[17] | - | - | - | + | ? | + | ? | + | - | + | ? | - | + | + | + | - | - | + | - | ? | + | - |
| Maia et al.[18] | - | - | ? | + | ? | + | + | + | + | + | + | ? | + | + | ? | - | - | + | - | ? | - | - |
| Martins et al.[19] | + | + | - | + | ? | + | ? | + | + | + | - | - | + | + | + | - | - | + | - | ? | - | - |
| Amorim et al.[20] | + | + | - | + | ? | + | - | + | + | + | + | + | + | + | + | - | - | + | - | ? | - | - |
| Monteiro et al.[21] | + | - | - | + | ? | + | ? | + | + | + | ? | - | + | + | + | - | - | + | - | ? | - | - |
| Azevedo et al.[25] | - | ? | - | + | + | + | ? | + | - | + | + | - | + | + | + | - | - | + | - | ? | - | - |
| Dudarewicz et al.[33] | - | + | - | + | + | + | ? | + | ? | + | ? | - | + | + | + | - | - | + | - | ? | - | - |

"+" data are presented, "-" data are missing and "?" data are incomplete

1-Title and abstract; 2-Background and rationale; 3-Objectives; 4-Study design; 5-Setting;6-Methods/Participants; 7-Variables; 8-Data sources/measurement; 9-Bias; 10-Study size; 11-Quantitative variables;12-Statistical methods; 13-Results/Participants; 14-Descriptive data; 15-Outcome; 16- Main results; 17-Other analyses; 18-Discussion/Results; 19-Discussion of Limitations; 20-Interpretation of results; 21-Generalisability of results; 22-Funding.

## DISCUSSION

Professional musicians are not always seen as a population at risk of developing NIHL as their profession is commonly associated with moments of leisure. However, music generates noise and, therefore, it may cause permanent hearing loss[22,23]. The increase in the power of amplifiers coupled with modern musical instruments can potentiate this problem.

The findings of this review show that noise-induced hearing loss is frequent in musicians and highlight the importance of studies on the hearing health of this population, both regarding the occurrence of auditory signs and symptoms and the use of

personal protective equipment. The identification of 13 articles that met the inclusion criteria demonstrates that the audiologic assessment of professional musicians is little discussed in the scientific community.

Researchers in Germany compared the incidence of hearing loss among 2,227 musicians and the general population from 2004 to 2008 and found that musicians were 3.51 times more likely to present NIHL and 1.45 times more likely to present tinnitus than the general population[24]. Other research has shown that the increase of hearing loss in musicians is expected, mainly due to the modernization of sound equipment that can generate more powerful sounds, which exposes them to higher sound pressure levels. In this regard, the prevalence of NIHL has been found to be similar to that found in workers in metallurgical industries[10]. The presence of audiometric notch, even at a single frequency, should be regarded as a warning sign as it suggests a tendency to trigger hearing loss by exposure to high sound pressure levels over time[10].

The lack of regulations on this profession makes it impossible to establish criteria to preserve the worker's health: determination of working hours, mandatory personal protective equipment, periodic hearing health checks[8,10]. According to some authors[7,12,14,16,20,21,25], the potential risk of NIHL exists in different musical fields (rock, sound trucks, symphonic orchestras, samba schools), not only in the collective use of musical instruments, but also in the individual use of these instruments. The study of risk factors for NIHL should take into account noise sources, length of stay in the noisy environment and use of protective equipment.

Most of the participants studied reported tinnitus, an auditory symptom that may indicate hearing loss but that needs to be confirmed by audiometric tests. When the body is exposed to high levels of sound pressure, it reacts to this stimulus, and such reactions can become permanent and create organic and psychological changes[26]. The impact of noise can disturb work, rest, sleep and communication in humans. A study on hearing, tinnitus and quality of life showed that tinnitus interfered with the emotional state and impacted sleep quality, concentration and social life[27]. In addition to the hearing-related symptoms, many professionals reported difficulty understanding speech in a noisy environment, intolerance to loud sounds, ear fullness, otalgia and dizziness, which suggests that continuous noise exposure also results in the appearance of extra-auditory symptoms which affect the well-being and, consequently, the musician's quality of life[28].

When studying the social implications of hearing impairment in adults, the difficulty of understanding speech leads to the difficulty of communication in the social group. Reports of family members' perceptions about the difficulties faced in the social environment are significant and contribute to understanding the exclusion experienced by people who have hearing loss, i.e., issues such as behavior change and irritation. The shame of asking people to repeat what they said or to speak louder makes them the victims of ridicule, contributing to the isolation and development of situations of stress, self-pressure and anxiety[2].

A lack of clarity and information regarding the use of PPE by musicians was evident in the studies, which suggests a more in-depth discussion about the need for individual perception of noise in the work environment and the risks to which these professionals are exposed, mainly because they often trivialize occupational hazards and are unable to identify the consequences of non-compliance with the use of prevention measures. Therefore, it is recommended that more than continuing education about hearing or hearing protection equipment, it is essential to create and implement a Hearing Loss Prevention Program (HLPP), which should aim to cause behavioral changes[6,29].

Methodological deficiencies were identified in the selected studies, mainly with regard to items 1, 3, 5, 7, 12, 17, 19, 20 and 21 of the STROBE Initiative, which refer to abstract structure, explanation of objectives, context in which the study was carried out, detail of study variables, statistical methods applied, extra analyses, presentation of study limitations, interpretation of results, and generalizations of results.

The lack of information on the methodology used in the studies evaluated in the present review limits a more comprehensive discussion of the results, which makes comparisons difficult. In the included studies, the methodology presented did not provide enough information to compare the results.

It should be noted that the scientific method is the way to construct knowledge and to replicate a study provided that it is adequately described[31,32]. The choice and description of the method used with detailed data allows an effective planning of the study and the investigation by other researchers. The STROBE Initiative provides a checklist of items that should be present in observational studies, contributing to the greater reliability of the research and to the reproducibility of the studies.

In this review, it was not possible to relate the hearing loss to the duration of daily exposure due to the lack of data presented in the original studies. Interpretations regarding the use of personal protective equipment as an instrument for hearing protection are limited because in most studies this issue has not been investigated. The methodological quality of the studies inhibits the possibility of elucidating the effects of noise on musicians' hearing, especially with regard to sound pressure levels and duration of exposure.

## CONCLUSION

Through this review it was possible to identify that the findings of the studies are consensual regarding the fact that musicians present noise-induced hearing loss, with tinnitus being the most frequent auditory symptom, a phenomenon which

indicates that there is alteration in the hearing of these professionals. The use of personal protective equipment, such as ear plugs, does not seem to be part of the routine of the study population.

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## CONFLICTS OF INTEREST

The authors declare there are no conflicts of interest.

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**First author's address:**
Carina Moreno Dias Carneiro Muniz
Universidade CEUMA
Rua Josué Montelo, 1
Bairro: Renascença 2
CEP: 65075-120 - São Luis - MA - Brasil
E-mail: carina.muniz@ifma.edu.br

**Mailing address:**
Rosane da Silva Dias
Universidade CEUMA
Rua Josué Montelo, 1
Bairro: Renascença 2
CEP: 65075-120 - São Luis - MA - Brasil
E-mail: rosanesdias@hotmail.com