



EFFECTIVENESS OF INTERVENTIONS PROMOTING HEARING HEALTH OR PREVENTING MUSIC-INDUCED HEARING LOSS AND/OR OTHER AUDITORY SYMPTOMS RELATED TO MUSICAL PRACTICE: A SYSTEMATIC REVIEW

ANÁLISE DA EFETIVIDADE DAS INTERVENÇÕES DE PROMOÇÃO DA SAÚDE AUDITIVA OU PREVENÇÃO DA PERDA AUDITIVA INDUZIDA PELA MÚSICA E/OU OUTROS SINTOMAS AUDITIVOS RELACIONADOS À PRÁTICA MUSICAL: UMA REVISÃO SISTEMÁTICA

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ABSTRACT

This research discusses the effectiveness of educational programs and preventive interventions aimed at promoting hearing health among musicians. The World Health Organization (WHO) highlights the risk of hearing loss due to noise exposure, including among musicians, where the prevalence of music-induced hearing loss (MIHL) can be significant. We emphasize the need for multidisciplinary approaches, integrating fields such as Music and Audiology, to mitigate these risks. The systematic review, conducted in line with the PRISMA 2020 protocol, focused on studies that evaluated the impact of hearing health interventions on musicians. The review identified four relevant studies, mostly from the United States and Australia, published between 2014 and 2022. These studies primarily focused on the use of hearing protection devices and educational programs to prevent hearing loss. The interventions showed effectiveness in increasing knowledge about hearing protection, changing harmful behaviors, and adopting safe practices. We concluded that while existing studies are limited in number and geographic scope, they demonstrate the efficacy of these programs. More research, especially targeting university music students, are important to develop more comprehensive and effective hearing health interventions tailored to the unique needs of musicians.

Keywords: Music. Students. Hearing loss. Noise-induced. Noise-induced hearing loss. Health promotion.

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RESUMO

Esta pesquisa apresenta uma revisão sistemática sobre a efetividade de programas educacionais e intervenções preventivas voltados à promoção da saúde auditiva entre músicos. A Organização Mundial da Saúde (OMS) ressalta o risco de perda auditiva decorrente da exposição ao ruído, incluindo no contexto musical, no qual a prevalência da perda auditiva induzida por música (PAIM) pode ser significativa. Enfatiza-se a necessidade de abordagens multidisciplinares, integrando áreas como a Música e a Fonoaudiologia, a fim de atenuar esses riscos. A revisão sistemática, conduzida de acordo com o protocolo PRISMA 2020, concentrou-se em estudos que avaliaram o impacto de intervenções voltadas à saúde auditiva em músicos. Foram identificados quatro estudos relevantes, majoritariamente provenientes dos Estados Unidos e da Austrália, publicados entre 2014 e 2022. Esses estudos enfocaram, principalmente, o uso de dispositivos de proteção auditiva e programas educativos para a prevenção da perda auditiva. As intervenções demonstraram efetividade no aumento do conhecimento sobre proteção auditiva, na modificação de comportamentos prejudiciais e na adoção de práticas seguras. Conclui-se que, embora os estudos existentes sejam limitados em número e abrangência geográfica, eles evidenciam a eficácia dessas intervenções. Ressalta-se a importância de novos estudos, especialmente voltados a estudantes universitários de Música, para o desenvolvimento de estratégias de promoção da saúde auditiva mais abrangentes e adaptadas às necessidades específicas da população de músicos.

Palavras-chave: Música. Estudantes. Perda auditiva. Perda auditiva provocada por ruído. Promoção da Saúde.

INTRODUCTION

The World Health Organization (Nelson et al., 2005, WHO, 2021) estimates that approximately 16% of hearing loss in adults is due to excessive noise exposure in the workplace and suggests preventive measures to preserve hearing. In recent years, educational programs have been implemented and evaluated with the aim of promoting hearing health and preventing hearing loss in children, adolescents, and adults exposed to noise (Brennan-Jones; 2020; Khan et al., 2018; Bramati et al., 2024).

The prevalence of music-induced hearing loss (MIHL) can reach up to 40% in this population (Di Stadio et al., 2018; Zhao et al., 2010; Pouryaghoub et al., 2017). In this context, hearing health promotion or prevention interventions for musicians are highly recommended and require a multidisciplinary integration between the fields of Music, Audiology, and related areas (Portnuff e Claycomb., 2019; Chesky, 2011; McGinnity et al., 2018).

Recent studies highlight the importance of evidence-based guidelines for caring for musicians' hearing (McGinnity et al., 2018), emphasizing the urgent need for collaborative approaches to mitigate the risks associated with musical exposure. This emphasizes the importance of implementing hearing health programs based on risk assessment and control measures, audiological evaluation, and awareness strategies (NIOSH, 2015; Zhao et al., 2010).

Given the above, this Systematic Review aims to analyze the effectiveness of health promotion and hearing loss prevention interventions in music students and professionals in this field.

MATERIALS AND METHODS

This systematic review was conducted in accordance with the PRISMA 2020 protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analysis Checklist) (Page et al., 2020). The research question was: What is the effectiveness of hearing health education programs for musicians?

Eligibility Criteria

The acronym "PICO", which was used to determine the eligibility of studies for this review, stands for:

- P = Population (Musicians: university students, graduates, and/or active professionals);
- I = Intervention (Interventions aimed at promoting hearing health and/or preventing music-induced hearing loss and/or other auditory symptoms related to musical practice such as tinnitus, diplacusis etc.);
- C = Comparison (before and after the intervention; the alternative intervention, control, or comparison group);
- O = Outcomes (increase in knowledge about hearing preservation, change in harmful habits or behaviors).

Inclusion Criteria

The included studies were conducted with music students and/or musicians aged 18 years or older. The studies included were intervention studies aimed at promoting hearing health and preventing music-induced hearing loss and/or other auditory symptoms related to musical practice (tinnitus, hyperacusis, diplacusis etc.). These studies presented a comparison between before and after the intervention (intragroup or intergroup). They were evaluated for the effectiveness of the intervention in terms of increasing knowledge about hearing prevention and changing harmful habits or behaviors related to hearing.

Exclusion Criteria

The studies excluded were the ones conducted with music students and/or musicians under 18 years of age; studies focused on evaluation, diagnosis, and rehabilitation concerning hearing; observational studies; systematic or scoping reviews, expert opinions, in vitro or animal studies, letters, conference abstracts, case reports, and case series, or case-control and cross-sectional studies that did not present a comparison between results before and after the intervention.

Information Sources and Search

Appropriate term combinations were selected and adapted for each of the following electronic databases: Embase, Latin American and Caribbean Health Sciences (LILACS), PubMed/Medline, Scopus, and Web of Science, along with four grey literature databases (ASHAWIRE, Google Scholar, OpenGrey, and ProQuest Dissertation and Thesis). Appendix A provides additional information on search strategies for all databases. Relevant studies on the subject were also solicited from experts in the field. References were checked, and duplicate items were removed using EndNote® software (EndNote® Basic X7 Thompson Reuters, New York, NY, USA). Searches were conducted on July 5, 2022, and updated on July 12, 2023.

Selection Process

The selection of articles was carried out in two phases. In the first phase, two reviewers (M.K.O. and N.N.) independently screened the titles and abstracts of all references. All articles that did not meet the previously established eligibility criteria were excluded at this stage. In the second phase, the same reviewers independently read the full texts of the articles selected in the first phase. When there was no consensus, even after discussion, a third reviewer (P.N.S.) was involved in the final decision.

To facilitate independent reading, the Rayyan site (<http://rayyan.qcri.org>) was used. In addition to the two reviewers conducting the blind evaluations, a third team member (P.N.S.) acted as a moderator.

Data Collection Process

The reviewers (M.K.O. and N.N.) collected information from the included studies, and those data were discussed. The collected data consisted of study characteristics (author, year of publication, country, study design), population characteristics (sample size, age range), evaluation characteristics (type of questionnaire, strategy), outcome characteristics (results presented concerning outcomes), and conclusions. Attempts were made to contact authors to retrieve any unpublished data if the necessary data were incomplete. Three attempts were made to contact the first author, corresponding author, and last author of the article, with a one-week interval between attempts.

The outcome of interest was the effectiveness of educational programs in hearing health. For studies where the applied tool provided results through scores, mean values, standard deviations, and sample size, the results were extracted from the studies and included in the synthesis for each group (control and experimental) or between different time points (pre- and post-intervention). Additionally, p-values were extracted for all comparisons.

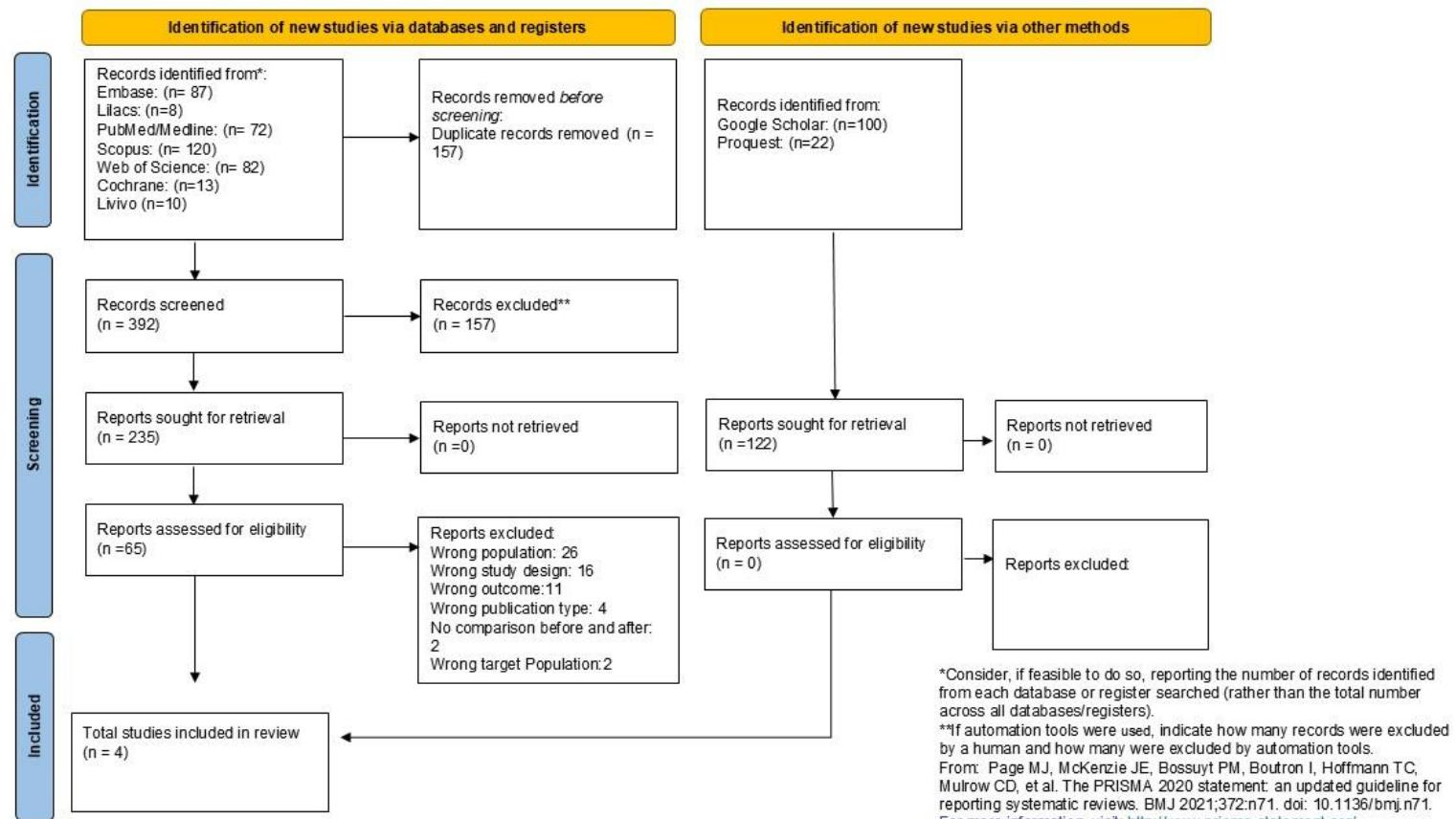
Criteria for Risk of Bias Analysis

The included studies were evaluated for methodological quality using the Joanna Briggs Institute Critical Appraisal Checklist (Joanna Briggs Institute, 2017). This tool covers 13 domains for randomized studies and nine domains for non-randomized studies. The judgment on the possible risk of bias in each of these domains was made by two independent reviewers (M.K.O. and N.N.), who used critical appraisal criteria to analyze all included articles, marking each criterion with "yes" or "no". If the study did not provide sufficient details, the risk of bias was considered "uncertain," and the original study authors were contacted for more information. When necessary, disagreements were resolved through discussion with a third researcher (P.N.S.).

RESULTS

Study Selection

Through the search strategy developed, the search in scientific databases resulted in 392 articles. After excluding 157 duplicate articles, 235 articles were selected for title and abstract screening. Out of these articles, four were selected for full-text reading (Figure 1).

Figure 1 - PRISMA 2020 flow diagram for updated systematic reviews which included searches of databases, registers and other sources

Source: Page et al., 2020.

Study Characteristics

All studies were found in English, with two originating from Australia and two from the United States. Two of the studies were published in 2014, one in 2020, and one in 2022. All of them had a qualitative nature, though some included both quantitative and qualitative aspects. All studies used pre- and post-intervention questionnaires.

Individual Study Results

Crawford et al. (2023): This study evaluated the effectiveness of hearing protection devices specifically designed for musicians. It involved objective measurements of noise attenuation provided by different types of hearing protection devices commonly used by musicians, such as conventional earplugs and musician-specific earplugs. Additionally, the researchers assessed factors like comfort, usability, and the fit of these devices, as well as the subjective experiences of musicians using them during practice or performances. The results provided insights into the effectiveness of hearing protection devices in preserving musicians' hearing health and recommendations for selecting suitable devices based on their performance characteristics and user preferences.

Nelson et al. (2020): This study explored the effectiveness of hearing protection among musicians and its impact on listeners' perceptions of music. It evaluated musicians' subjective experiences with hearing protection, including comfort, ease of use, and overall satisfaction. Additionally, experiments were conducted to determine if the audience could perceive any difference in music produced by musicians using hearing protection compared to those not using any. The results demonstrated musicians' positive response to hearing protection and highlighted the effectiveness of these measures in preserving hearing health without compromising the perceived quality of music by the audience.

O'Brien et al. (2014): This study evaluated the effectiveness of active hearing protection among orchestra musicians. The controlled study involved participants receiving active hearing protection devices designed to mitigate the risks of hearing loss associated with prolonged exposure to high sound levels in orchestral settings. It included objective measurements of participants' hearing levels before and after using active

hearing protection, as well as subjective evaluations of comfort, usability, and overall satisfaction with the devices. The results evidenced the effectiveness of active hearing protection in preserving the hearing health of orchestra musicians, recommending future interventions and practices to reduce the incidence of hearing loss in this population.

O'Brien et al. (2015): This study implemented and evaluated a hearing conservation program in a professional symphony orchestra. The program included various interventions aimed at protecting the hearing health of orchestra members, such as education on hearing protection, regular monitoring of noise exposure levels, and provision of suitable hearing protection devices. The study provided a detailed description of the program components, implementation process, and strategies employed to promote hearing health among orchestra musicians. Additionally, the authors assessed the program's effectiveness through objective measurements of hearing status, subjective feedback from participants, and comparisons with control groups. The results demonstrated the effectiveness of hearing conservation programs tailored to the unique needs of professional orchestra musicians.

Risk of Bias

The four analyzed articles presented a low risk of bias (Figure 2).

Figure 2 - Risk of Bias

Study	Risk of bias								
	D1	D2	D3	D4	D5	D6	D7	D8	Overall
Crawford et al. (2022)	+	+	+	+	+	+	+	+	+
Nelson et al. (2020)	+	+	+	+	+	X	+	+	+
O'Brien et al. (2014)	+	+	+	+	+	+	+	+	+
O'Brien et al. (2015)	+	+	+	+	+	+	+	X	+

D1: Were the criteria for inclusion in the sample clearly defined?
 D2: Were the study subjects and the setting described in detail?
 D3: Was the exposure measured in a valid and reliable way?
 D4: Were objective, standard criteria used for measurement of the condition?
 D5: Were confounding factors identified?
 D6: Were strategies to deal with confounding factors stated?
 D7: Were the outcomes measured in a valid and reliable way?
 D8: Was appropriate statistical analysis used?

Judgement
 ● High
 + Low

Source: Research data.

DISCUSSION

Collectively, the four studies included in this review demonstrate that interventions emphasizing educational strategies and the use of hearing protectors are effective in promoting hearing health and reducing the risk of music-induced hearing loss (MIHL) among musicians. However, their impact is limited by low adherence rates, variability in earplug comfort and performance, and the lack of long-term follow-up evaluations. These findings underscore the need for comprehensive, multi-component hearing conservation programs that address both individual behaviors and environmental conditions to achieve sustainable outcomes.

Although the number of studies focusing on hearing health promotion among musicians has grown in recent years, research in this field remains limited, with publications concentrated between 2014 and 2022. Of the four studies included, three primarily examined preventive actions related to hearing protection, while one implemented a broader hearing health program encompassing multiple preventive dimensions. All studies presented a low risk of bias, reinforcing the reliability of their results despite their limited scope.

According to the National Institute for Occupational Safety and Health (NIOSH, 2015), an effective hearing conservation program for musicians should integrate several key components. Health education is fundamental to increasing awareness of MIHL risks and encouraging the adoption of preventive behaviors. Musicians should receive guidance on safe listening practices, proper earplug use, and the importance of regular audiometric monitoring. Additionally, engineering and administrative controls—such as sound level monitoring, acoustic treatment of rehearsal spaces, and scheduling regular breaks—are essential to mitigate prolonged exposure to high-intensity sounds.

The populations examined across the studies included music students and professional orchestra members, reflecting a heterogeneous demographic in terms of musical genre, performance setting, and occupational exposure (Ismail et al., 2022; Burland & Pitts, 2007). Studies by O'Brien et al. (2014, 2015) adopted mixed methodologies, using both structured and open-ended questionnaires to assess interventions, allowing participants to express doubts and suggestions—an approach that

facilitates tailoring educational content to specific population needs. Similarly, O'Brien et al. (2014) and Crawford et al. (2022) evaluated hearing protector effectiveness using pre- and post-intervention questionnaires, reporting favorable outcomes for Etymotic silicone earplugs in terms of attenuation and user acceptance. Nonetheless, Crawford et al. (2022) emphasized the need for further investigation regarding the comfort and performance of foam earplugs.

All studies concurred that preventive actions should extend beyond the mere provision of hearing protectors, aligning with NIOSH's (2015) recommendation for comprehensive hearing conservation programs. O'Brien et al.'s (2015) intervention exemplified this approach by involving both musicians and backstage personnel in an integrated program comprising sound pressure level monitoring, health education, engineering and administrative measures, and regulatory development.

The geographical context of the studies—limited to the United States and Australia—also warrants consideration. While the United States lacks national public policies or labor legislation specifically addressing musicians' hearing health, several professional associations provide non-regulatory guidance. In contrast, the United Kingdom's *Control of Noise at Work Regulations* (2005) established mandatory criteria to mitigate hearing risks in the music sector. Other countries, including Australia, Switzerland, Italy, Austria, Finland, and Sweden, have also implemented recommendations for hearing conservation among musicians.

It is particularly relevant that music students are not typically covered by occupational noise regulations, as they are not legally recognized as employees. Nonetheless, university environments often expose them to prolonged and intense sound levels during rehearsals and performances, placing them at risk comparable to professional musicians. Therefore, future research should prioritize the development and evaluation of targeted hearing health interventions for university musicians, ensuring the early adoption of safe listening practices and contributing to the long-term preservation of hearing health in this population.

CONCLUSION

In response to the research question on the effectiveness of educational programs in auditory health for musicians, it is concluded that existing programs, although limited in number, demonstrate significant efficacy. The reviewed studies indicate that these programs are effective in promoting knowledge about auditory protection, changing habits harmful to hearing, and adopting safe behaviors among musicians.

The results from the systematic review highlight interventions, such as the use of specific ear protection for musicians, educational programs on auditory health, monitoring of noise exposure levels, and appropriate regulations can positively, contribute to preserving musicians' hearing. These interventions not only increase awareness of the risks of music-induced hearing loss, but also encourage safe practices that help mitigate these risks.

It is important to note that the effectiveness of these programs depend on the integration of multiple components, such as health education, acoustic control in work environments, and proper use of hearing protection equipment. Additionally, the inclusion of all types of musicians, from university students to orchestra professionals, is crucial order to address the diverse needs of this population.

Therefore, despite the scarcity of studies and their limited geographic focus, existing programs show promise and provide a solid foundation for future research and the development of public policies aimed at musicians' auditory health. Further research is needed to expand knowledge in this area and develop even more effective interventions tailored to the unique characteristics of this singular population.

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APPENDIX A

Pubmed	("students"[MeSH Terms] OR "students" OR "student" OR "music student" OR "music students" OR "academic music education" OR "college music students" OR "university music students" OR "musicians" OR "musician") AND ("preventive health care"[MeSH Terms] OR "preventive health care" OR "preventive health" OR "preventive health service" OR "preventive health programs" OR "preventive health program" OR "preventive programs" OR "preventive program" OR "hearing conservation intervention" OR "hearing conservation program" OR "hearing conservation") AND ("hearing" OR "hearing conservation program" OR "hearing preservation program" OR "hearing conservation programme" OR "hearing preservation programme" OR "hose-induced hearing loss")
Lilacs	("students" OR "student" OR "music student" OR "music students" OR "academic music education" OR "college music students" OR "university music students" OR "musicians" OR "musician" OR "estudantes" OR "estudante" OR "estudante de música" OR "estudantes de música" OR "educação musical acadêmica" OR "estudantes universitários de música" OR "estudante universitário de música" OR "músicos" OR "músico" OR "estudiantes" OR "estudiante" OR "estudiante de música" OR "estudiantes de música" OR "educación musical académica" OR "estudiantes universitarios de música" OR "estudiante universitario de música" OR "étudiants" OR "étudiant" OR "étudiant en musique" OR "étudiants en musique" OR "enseignement musical universitaire" OR "étudiants en musique au niveau collégial" OR "étudiants universitaires en musique" OR "musiciens" OR "musicien") AND ("preventive health care" OR "preventive health" OR "preventive health service" OR "preventive health programs" OR "preventive health program" OR "preventive programs" OR "preventive program" OR "hearing conservation intervention" OR "hearing conservation program")

Received: 06/03/2025

Accepted: 11/14/2025