



# International research shows that musicians are three times more likely to suffer from tinnitus than the general population.

*One-third of Dutch music professionals with tinnitus experience severe limitations.*

**Amsterdam, March 2026.**

Musicians are more than three times more likely to suffer from tinnitus than the general population. This is according to a large-scale international meta-analysis recently published in the scientific journal *Otolaryngology–Head and Neck Surgery*.

Exploratory research by the TinnitusFree Foundation among Dutch music professionals confirms this picture. One third of the participants experience tinnitus symptoms that severely limit their daily functioning and professional practice.

## **Musicians are structurally at greater risk of hearing problems**

The international meta-analysis by McCray and colleagues combined 67 scientific studies involving a total of 28,311 musicians from 21 countries. The results show clear differences between musicians and the general population. Tinnitus is reported by 42.6 percent of musicians, compared to 13.2 percent in the general population. Hearing loss and hyperacusis, a hypersensitivity to sound, are also significantly more common. It is striking that the genre of music does not play a protective role. Classical musicians and pop and rock musicians run similar risks of hearing problems.

## **Dutch figures show major impact**

In 2025, the TinnitusFree Foundation conducted an exploratory study among 137 Dutch music professionals with tinnitus. The participants completed the Tinnitus Functional Index (TFI), an internationally validated questionnaire that measures the severity and impact of tinnitus. The average score of 48.9 on a scale of 0 to 100 indicates moderate to severe tinnitus. Thirty-six percent of participants reported mild symptoms, while 33 percent experienced very severe tinnitus. This group experiences daily discomfort, with consequences for sleep, concentration, social activities, and the practice of their profession.

"The international study shows how widespread tinnitus is among musicians," says the TinnitusFree Foundation. "Our research reveals how significant the impact can be. For a substantial proportion of music professionals, tinnitus is a serious obstacle to their work and daily life."

## **Major disease burden. Limited treatment options**

Despite its high prevalence and significant personal and social impact, there are currently no curative treatments for tinnitus. The available care focuses mainly on symptom management. According to the TinnitusFree Foundation, the scale of the problem is disproportionate to the resources available worldwide for fundamental and clinical tinnitus research.

### **From creators to listeners: Tinnitus on the rise among young people**

Tinnitus is not only an occupational problem for musicians, but also a growing health problem among young people. The number of young people with tinnitus in the Western world has doubled in recent years, mainly due to the use of earbuds and exposure to noise in nightclubs, at festivals, and at concerts.

TinnitusFree emphasizes that the Dutch study is a first quantitative inventory. "With this study, we show how great the burden of disease is among music professionals. The next step is medical-scientific research into underlying mechanisms, risk profiles, and treatment options. Without that in-depth research, tinnitus will remain a chronic condition with no prospect of recovery."

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# Tinnitus in Professional Musicians: A Cross-sectional Study of Prevalence and Impact

*TinnitusFree Foundation, March 2026*

**Objective.** To determine the prevalence and severity of tinnitus among professional musicians, with a focus on functional impact and comorbidities.

**Method.** Cross-sectional questionnaire survey among 137 professional musicians with tinnitus, conducted in 2025. The Tinnitus Functional Index (TFI) was used to measure severity and functional impact.

**Results.** The mean TFI score was 48.9 (SD = 36.0), indicating moderate to severe tinnitus burden. Of the participants, 35.8% fell into the mild category, 23.4% into the moderate category, 7.5% into the severe category, and 33.3% into the very severe category. Approximately 23% of musicians never wear hearing protection while working.

**Conclusion.** Tinnitus is a significant impediment for professional musicians. The results emphasize the importance of preventive measures, regular hearing checks, and adequate support for musicians with tinnitus.

## Introduction

Noise-induced hearing loss (NIHL) is the most common cause of sensorineural hearing loss in adults after presbycusis (age-related hearing loss). Professional musicians are at increased risk due to their prolonged and regular exposure to high noise levels, often above 85 dB(A). Recent meta-analytic research by McCray et al. (2026) showed that 42.6% of musicians report tinnitus, compared to 13.2% in the general population.

Tinnitus, the perception of sound without an external source, is a common comorbidity of hearing loss. The condition can lead to significant limitations in daily functioning, including sleep problems, difficulty concentrating, anxiety, and depression. For musicians, tinnitus can be particularly problematic, as it directly affects their ability to hear clearly and perform music.

Despite the high prevalence of hearing complaints among musicians, only a minority consistently wear hearing protection. Previous research shows that approximately 23% of musicians never wear hearing protection while working. Barriers to the use of hearing protection include its impact on the musical experience and interaction with fellow musicians.

The aim of this study is to map the prevalence and severity of tinnitus among professional musicians, with specific attention to the functional impact measured with the Tinnitus Functional Index (TFI), the use of hearing protection, and the influence on professional practice.

Method

## Research design

This cross-sectional study was conducted by the TinnitusFree Foundation in 2025. Professional musicians with tinnitus were recruited through musician networks and social media. Inclusion criteria were: (1) professional musician, (2) experience with tinnitus, and (3) age 18 years or older.

### Measuring instruments

The questionnaire consisted of several sections: demographic data and musical background (type of musician, instrument, style), use of hearing protection (frequency, type, duration), awareness of tinnitus risk, experience with hearing protection, tinnitus duration and cause, comorbidities (hearing loss, mental health, postural complaints), impact on professional practice, and the Tinnitus Functional Index (TFI).

The Tinnitus Functional Index (TFI) is a validated instrument consisting of 25 items, each scored on a scale of 0-10. The total score (0-100) reflects the severity of the tinnitus burden: 0-17 = not problematic, 18-31 = mild problem, 32-53 = moderate problem, 54-72 = severe problem, 73-100 = very severe problem.

### Statistical Analysis

Data were analyzed using SPSS. Descriptive statistics were calculated for all variables. Means and standard deviations were reported for continuous variables; frequencies and percentages for categorical variables.

### Results

A total of 137 professional musicians with tinnitus were included. The study population consisted of musicians with diverse musical backgrounds. Data collection took place on February 3, 2026. Table 1 provides an overview of the study characteristics.

**Table 1. Study characteristics**

Characteristic	Value
Number of participants (n)	137
Population	Professional musicians with tinnitus
Type of study	Cross-sectional questionnaire survey
Data collection	February 3, 2026
Geographical distribution	International (multiple countries)

### Tinnitus Functional Index (TFI)

The average TFI score was 48.9 (SD = 36.0) on a scale of 0-100, which corresponds to moderate to severe tinnitus severity. The distribution of TFI scores across severity categories is shown in Table 2.

**Table 2. Distribution of TFI scores across severity categories**

Severity category	TFI score	Percentage
Non-problematic/Mild	0	35.8
Moderate	32	23.4
Severe	54 - 72	7.5
Very serious	73 - 100	33

It is striking that a substantial proportion (33.3%) of participants experience very severe tinnitus (TFI  $\geq 73$ ), while 35.8% report mild symptoms. This indicates a bimodal distribution of tinnitus severity within this population.

### Table 3. TFI statistics

Statistic	Value
Average TFI score	48.9
Standard deviation (SD)	36.0
Number of valid TFI responses	16,552
Not applicable (N/A)	2,080

### Hearing protection

The use of hearing protection among professional musicians remains an important issue. Based on the data from this study and comparison with international literature, the use of hearing protection is shown in Table 4.

### Table 4. Use of hearing protection among professional musicians

Frequency	Percentage
Always	~23
Most of the time	~26%
Sometimes	~19%
Rarely	~13%
Never	~23%

Note: Percentages based on comparison with international literature (Burns-O'Connell et al.)  
Comparison with International Data

### Table 5 compares the findings of this study with the results of the recent meta-analysis by McCray et al. (2026), which included 67 studies with 28,311 musicians.

#### Table 5. Comparison of prevalence of hearing complaints: Current study vs. McCray et al. (2026)

Symptom	Musicians (McCray)	Control group
Tinnitus	42.6	13.2
Hearing loss	25.7	11.6
Hyperacusis	37.3	15.3

The meta-analysis showed significantly higher prevalence rates for all auditory symptoms in musicians compared to the general population ( $p < 0.0001$  for all comparisons).

### Discussion

This study of 137 professional musicians with tinnitus shows that the tinnitus burden within this population is substantial, with an average TFI score of 48.9. This falls within the 'moderate problem' category according to the TFI classification, but the high standard deviation (36.0) indicates large individual differences.

The bimodal distribution of tinnitus burden is striking: while 35.8% of participants experience only mild burden, 33.3% report very severe burden (TFI  $\geq 73$ ). This suggests that the impact of tinnitus varies greatly between individuals, possibly influenced by factors such as coping strategies, psychological resilience, social support, and the duration of the tinnitus.

Our findings are consistent with the meta-analysis by McCray et al. (2026), which showed that musicians report tinnitus (42.6% vs. 13.2%), hearing loss (25.7% vs. 11.6%), and hyperacusis (37.3% vs. 15.3%) significantly more often than non-musicians. This confirms that, despite its many benefits, playing music poses a significant risk to hearing health.

The fact that approximately 23% of musicians never wear hearing protection is concerning. Barriers to the use of hearing protection include: the impact on the musical experience, problems hearing fellow musicians, and a dull feeling in the ear. This underscores the need for better education and the development of more comfortable hearing protection specifically for musicians.

### **Limitations**

This study has some limitations. First, it involves a selective sample of musicians who have registered with the TinnitusFree Foundation, which may lead to selection bias. Second, tinnitus is based on self-reporting, without objective audio metric confirmation. Third, the data on hearing protection are largely based on comparisons with international literature.

### **Clinical Implications**

The results have important implications for practice. Prevention remains essential: conservatories and music schools should provide systematic education about hearing risks and the use of hearing protection. Regular audiometric checks are recommended for professional musicians. Musicians with tinnitus need adequate support, including access to specialized care and psychological counseling if necessary.

### **Conclusion**

This study shows that tinnitus is a significant barrier for professional musicians. With an average TFI score of 48.9 and one-third of participants in the 'very severe' category, it is clear that tinnitus is a serious occupational disease that deserves more attention.

The findings emphasize the importance of: (1) preventive measures and education, particularly in the early stages of training, (2) development of effective and comfortable hearing protection for musicians, (3) regular hearing checks as part of occupational health, and (4) adequate support and treatment for musicians with tinnitus.

Future research could focus on longitudinal studies of the progression of tinnitus in musicians, the effectiveness of various interventions, and the development of music-specific tinnitus treatment programs.

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# Auditory Symptoms Among Musicians: A Systematic Review and Meta-analysis

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## Abstract

**Objective.** To assess the prevalence of auditory symptoms among recreational and professional musicians.

**Data Sources.** CINAHL, Cochrane Library, PubMed, and SCOPUS were searched for English-language studies published from inception through November 19, 2024.

**Review Methods.** We included cohort and cross-sectional studies reporting auditory symptom prevalence among recreational or professional musicians at least 18 years old. Studies involving children or noise exposure data only were excluded. Data were extracted independently by two authors, with disagreements resolved by discussion. Risk of bias was assessed using the Risk Of Bias In Nonrandomized Studies - of Exposure for prospective cohort studies, the Joanna Briggs Institute (JBI) checklist for retrospective cohort and cross-sectional studies, and the Risk of Bias 2 tool for randomized controlled trials. Primary outcome measures included continuous measures (mean) and proportions (%) with 95% confidence intervals.

**Results.** Sixty-seven studies (n = 28,311) on auditory symptoms among musicians were included. The mean age was 34.7 years for the musicians and 30.2 years for the control group. Musicians experienced a significantly higher prevalence of tinnitus (42.6% vs 13.2%), hearing loss (25.7% vs 11.6%), and hyperacusis (37.3% vs 15.3%) compared to the control population. However, there was no significant difference in the prevalence of hearing loss, hyperacusis, and tinnitus between classical and pop/rock musicians.

**Conclusion.** At least one in three musicians reports tinnitus or hyperacusis, while approximately one in four has hearing loss. This evidence suggests otolaryngologists treating musicians should consider routine auditory assessments and preventive counseling.

## Keywords

hearing loss, hyperacusis, musician, tinnitus

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**N**oise-induced hearing loss (NIHL) is the second-most common cause of sensorineural hearing loss (SNHL) in adults, with 25% of US adults

having a measured hearing loss secondary to noise exposure.<sup>1,2</sup> Both professional and recreational musicians are at increased risk for NIHL given their consistent exposure to high noise levels (>85 A-weighted decibels [dB (A)]), leading to direct mechanical stress on cochlear hair cells, calcium overload, and the formation of reactive oxygen species.<sup>2,3</sup> Many musicians express concern about permanent hearing impairment; however, fewer than 50% regularly utilize hearing protective devices (HPDs).<sup>4</sup>

SNHL is the most well-described consequence of noise exposure among musicians, but tinnitus and hyperacusis are also prevalent and clinically significant.<sup>5</sup> In addition, the nature of a particular instrument could lead to asymmetric or unilateral symptoms, such as violinists having worse hearing on the left side due to the positioning of the instrument on the player's left shoulder.<sup>6</sup> In contrast, pop or rock musicians generally present with more symmetric symptoms and might have higher rates of NIHL.<sup>7</sup>

The goal of this systematic review and meta-analysis is to characterize and quantify rates of NIHL, while providing a more in-depth picture of the frequency and quality of tinnitus and hyperacusis. This review will examine the risk of occupational otologic conditions among musicians and discuss the clinical implications.

## Methods

### Data Collection and Selection

This study was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.<sup>8</sup> Our PICO question was the following: What is the prevalence of auditory symptoms

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such as tinnitus, hearing loss, and hyperacusis among musicians compared to non-musicians? Before conducting our search, the review protocol was registered on PROSPERO (CRD42024616279). PubMed (National Library of Medicine – National Institutes of Health), Scopus (Elsevier), CINAHL Complete (EBSCOhost), and Cochrane Library (Wiley) databases were searched from inception through November 19, 2024, by authors L.R.M. and A.T.R. Specific search strategies were used for each database with a combination of medical subject headings and the following key words: hearing loss, tinnitus, hyperacusis, music, orchestra, and band. An example of our search strategy is provided in Supplemental A, available online. Reference lists of relevant articles were also searched. References were uploaded to Covidence (Veritas Health Innovation Ltd., Melbourne, Australia) and screened for relevance by authors L.R.M. and A.T.R.

### Selection Criteria

Studies with the primary objective of assessing the prevalence of auditory symptoms among musicians at least 18 years old were included. Recreational and professional musicians of any genre were included. Studies were excluded if they provided unspecified auditory symptoms, reported noise exposure or risk assessment data without assessing auditory symptoms, or presented data in figures that could not be extracted. Non-English-language papers, studies of non-human subjects, and abstracts were excluded. Cross-sectional and cohort studies were included. Case studies and case reports were excluded.

### Data Extraction

Basic study information (eg, author, year) and patient information (eg, sex, age) were extracted. If provided, information about the genre, setting, and length of music exposure was extracted for musicians. The prevalence of auditory symptoms, including tinnitus, hearing loss, and hyperacusis, was extracted for both musicians and non-musician control participants. No specific method of assessing auditory symptoms was used as a basis for inclusion or exclusion in this study. The level of evidence for each selected article was evaluated using the Oxford Centre for Evidence-Based Medicine criteria.<sup>9</sup>

### Quality Assessment

Risk of bias was assessed according to the Joanna Briggs Institute (JBI) critical appraisal checklist for cross-sectional studies<sup>10</sup> and the Risk of Bias 2 (RoB 2) tool for randomized controlled trials (RCTs).<sup>11</sup> Prospective cohort studies were assessed with the Risk Of Bias In Nonrandomized Studies - of Exposure (ROBINS-E),<sup>12</sup> while retrospective cohort studies were assessed with the JBI critical appraisal checklist for cohort studies.<sup>13</sup> Each

question on the JBI cross-sectional and cohort checklist was given a score of “1” for “yes” and “0” for “no,” “not applicable,” or “unclear.” A score of at least 4 out of 8 for the cross-sectional checklist and 5 out of 11 for the cohort checklist was considered at low risk for bias. In addition, each aspect of risk of bias in the ROBINS-E and RoB 2 tools was assigned a grade of low, unclear, or high. One author (J.C.P.) performed a risk assessment on all studies included in the meta-analysis, while another author (L.R.M.) checked his work for accuracy. Disagreements were resolved by way of a third author (S.A.N.). Risk of bias items included the following: inclusion criteria, selection bias, measure of exposure, confounding factors, validity and reliability of outcome measures, appropriate statistical analysis, and other criteria.

### Statistical Analysis

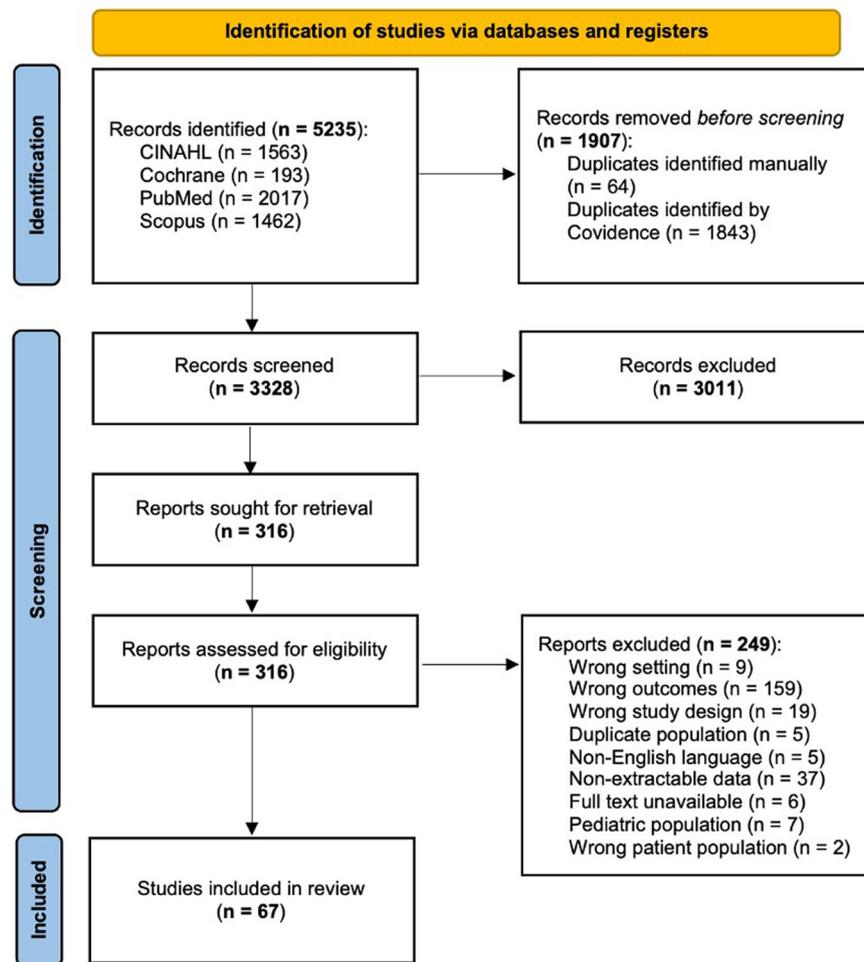
Meta-analysis of continuous measures (age, length of musical practice, etc.) and meta-analysis of proportions (gender, hearing loss, tinnitus, etc.) were performed using MedCalc 23.0.2 (MedCalc Software). Each measure (mean/proportion [%]/proportion difference [ $\Delta\%$ ] and 95% confidence interval [CI]) was weighted according to the number of patients affected. Heterogeneity among studies was assessed using  $I^2$  statistics with fixed effects ( $I^2 < 50\%$ ) and random effects ( $I^2 \geq 50\%$ ). In addition, a comparison of proportions, expressed as difference ( $\Delta\%$ ) and 95% CI, was done to compare outcomes between musicians and the control population. Finally, potential publication bias was evaluated by visual inspection of the funnel plot and Egger's regression test, which statistically examines the asymmetry of the funnel plot.<sup>14,15</sup> A  $P$ -value of  $<.05$  was considered significant for all statistical tests.

## Results

### Study Characteristics

After removing duplicates, 3328 titles and abstracts were screened for inclusion. Of those studies, 316 underwent full-text review, and 67 were ultimately included for analysis (Figure 1).<sup>3,5,6,16-79</sup> The included studies, published between 1981 and 2024, comprised 3,418,914 participants, of whom 28,311 were musicians. The musician population was 66.6% male (95% CI: 63.0%-70.1%) with an average age of 34.7 years (95% CI: 30.0-39.5 years). The average length of musical practice was 14.6 years (95% CI: 11.8-17.3 years). The control population was 54.2% male (95% CI: 50.7%-57.6%) with an average age of 30.2 years (95% CI: 26.1-34.2 years).

The studies represented twenty-one countries across North America, Europe, Asia, Africa, Australia, and South America, with the largest portion from the United States. The genres and setting of music exposure varied widely, including undergraduate music students, symphony orchestra members, rock and roll musicians,



**Figure 1.** Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) diagram. Flowchart depicting study attrition through screening and eligibility assessments.

disc jockeys, and carnival performers, among others. A summary of study characteristics is provided in **Table 1**.

### Quality Assessment

Based on Oxford Level of Evidence criteria, the 55 cross-sectional studies and 2 retrospective cohort studies present level 4 evidence. The nine prospective cohort studies present level 3 evidence, while the RCT presents level 2 evidence. JBI appraisal of the cross-sectional studies (**Table 2**) and cohort studies (Supplemental Table S1, available online) resulted in a score of 5 or higher for all studies, suggesting good quality and low risk of publication bias. Critical appraisal of the included studies indicated an acceptably low risk of bias for the majority (**Figure 2** and Supplemental Figure S1, available online). The RCT was judged to have an overall low risk of bias, although there was some uncertainty regarding allocation concealment and the blinding of participants and study personnel (Supplemental Figure S1, available online). Most nonrandomized studies were also assessed as having a low risk of bias; however, they were more susceptible to potential confounding and selection bias.

Finally, a funnel plot with Egger's test (1.5; 95% CI:  $-4.5$  to  $7.4$ ;  $P = .61$ ) demonstrated that 13 out of 21 studies were found within the funnel, suggesting low publication bias (**Figure 3**).

### Prevalence of Auditory Symptoms

As depicted in **Table 3**, musicians experienced a significantly higher prevalence of tinnitus, hearing loss, and hyperacusis compared to the control population. Among these symptoms, musicians most commonly reported tinnitus, followed by hyperacusis and hearing loss. Of the musicians who reported tinnitus, 15.6% (95% CI: 13.0%-18.6%) described it as permanent, while 76.3% (95% CI: 60.5%-89.0%) reported it as occasional. Among musicians with hearing loss, 36.5% (95% CI: 16.1%-59.9%) of cases were diagnosed based on objective measures, whereas 63.5% (95% CI: 40.1%-83.9%) were based on subjective report. Furthermore, there was no significant difference in the prevalence of hearing loss, hyperacusis, and tinnitus between classical and pop/rock musicians (**Figure 4**). In the control group, 9.5% (95% CI: 0.3%-39.1%) of hearing loss cases were determined

**Table 1.** Characteristics of Included Studies

Study (year)	Country	OLE	Type of musicians	Musicians (n)	Males (n)	Average age in years (mean (SD))
Ackermann et al. (2014)	Australia	4	Symphony orchestra	377	184	42.1 (10.2)
Alcala Rueda et al. (2023)	Spain	4	Classical orchestra	194	-	-
Axelsson et al. (1995)	Sweden	3	Pop/rock musicians	53	-	41.2
Barlow (2010)	United Kingdom	4	Undergraduate music students	100	92	22.6
Barlow (2011)	United Kingdom	4	Undergraduate music students	50	44	-
Bhatt et al. (2021)	United States	3	Music majors	186	99	20.3
Boissinot et al. (2022)	Canada	4	Pianists	17	12	24
Brar et al. (2023)	United States	4	Singers	206	43	44.9 (16.5)
Bray et al. (2004)	United Kingdom	4	Disc jockeys	23	18	29
Callahan et al. (2011)	United States	4	College musicians	130	69	19.4 (1.3)
Cândido et al. (2012)	Brazil	4	Dance band	10	-	32.9 (12.4)
Carneiro Muniz et al. (2021)	Brazil	4	Folklore music group	41	24	-
Chesky and Henoeh (2000)	United States	4	Professional musicians	3293	-	33.7
Couth et al. (2019)	United Kingdom	4	Performing musician, director, or conductor	395	234	54.9 (7.9)
Couth et al. (2020)	United Kingdom	4	Music performance students	76	36	-
Crawford et al. (2023)	United States	4	Instructors and grad students at school of music	24	-	-
Dance and Zepidou (2024)	United Kingdom	4	Classical music students	5300	2544	-
Dinakaran et al. (2018)	India	4	Professional musicians	36	-	27.8
Dreyer et al. (2023)	South Africa	4	University music faculty	40	21	-
Gopal et al. (2013)	United States	4	Music majors	14	14	24 (3.9)
Gunduz et al. (2022)	Turkey	4	Violinists	25	12	20.4 (2.7)
Hasson et al. (2009)	Sweden	4	Symphony orchestra	250	155	39 (9)
Helena Mendes et al. (2007)	Brazil	3	Band members	34	28	40
Hoffman et al. (2006)	United States	4	Percussionists	315	240	30.9
Jansen et al. (2009)	Netherlands	4	Symphony orchestra	241	129	44.4 (10.2)
Jin et al. (2013)	United States	3	College marching band	350	176	-
Kahari et al. (2003)	Sweden	4	Rock/jazz musicians	139	96	-
Laitinen (2005)	Finland	4	Professional orchestra	196	134	-
Laitinen and Poulsen (2008)	Denmark	4	Symphony orchestra	145	88	-
Luders et al. (2014)	Brazil	4	Music students	42	26	26.0 (7.7)
Luders et al. (2016)	Brazil	4	Professional musicians	100	-	-
Maia and Russo (2008)	Brazil	4	Rock and roll musicians	23	19	-
McGinnity et al. (2021)	Australia	4	Live-music sound engineers	27	25	34 (9)
Miller et al. (2007)	United States	4	Student musicians	27	21	20
Nambiar et al. (2024)	United States	4	Yakshagana artists	96	96	-
Niarchou et al. (2021)	United States	3	Musicians	9803	5686	47.8 (17.2)
O'Brien et al. (2014)	Australia	4	Orchestral musicians	367	172	42.7 (10.5)
Olson et al. (2016)	United States	4	College musicians	90	-	-
Ostri et al. (1989)	Denmark	4	Orchestral musicians	96	80	43.7 (8.7)
Parra et al. (2018)	Spain	4	Music students	43	17	-
Patil et al. (2013)	United Kingdom	3	Military musicians	84	84	29
Pawlaczyk-Łuszczczyńska et al. (2017)	Poland	4	Music students	168	86	22.8 (2.5)
Pawlaczyk-Łuszczczyńska et al. (2021)	Poland	3	Music students	163	83	22.8 (2.6)

(continued)

**Table 1.** (continued)

Study (year)	Country	OLE	Type of musicians	Musicians (n)	Males (n)	Average age in years (mean (SD))
Potier et al. (2009)	France	4	Disc jockeys	29	-	26.4 (5.7)
Pouryaghoub et al. (2017)	Iran	4	Musicians	125	104	35.9 (9.1)
Raeburn et al. (2003)	United States	4	Pop musicians	226	181	68
Ramma et al. (2021)	South Africa	4	Minstrel carnival musicians	43	21	21 (9)
Raymond et al. (2012)	United States	4	Classical musicians	32	12	-
Royster et al. (1991)	United States	4	Symphony orchestra	59	46	52.4
Ryan et al. (2023)	United Kingdom	4	Choir singers	18	5	-
Samelli et al. (2012)	Brazil	3	Pop/rock musicians	16	-	27.1 (6.0)
Schink et al. (2014)	Germany	4	Professional musicians	2227	1257	39.7 (11.6)
Schmidt et al. (2019)	Denmark	4	Symphony orchestra	325	194	-
Schmuziger et al. (2006)	Switzerland	4	Pop/rock musicians	42	37	33.0 (8.7)
Schurig et al. (2024)	Germany	4	Professional and amateur musicians	198	-	-
Seever et al. (2018)	United States	2	College band members	43	-	-
Setiawan and Maryati (2018)	Indonesia	4	Jegog players	37	37	38.0 (8.4)
Steurer et al. (1998)	Austria	4	Choir singers	57	29	-
Topoglu et al. (2018)	Turkey	4	Symphony orchestra	220	121	42.4 (11.3)
Toppila et al. (2011)	Finland	4	Symphony orchestra	63	38	40 (6)
Unsal and Bal (2021)	Turkey	4	Music teachers	17	6	26.4 (5.6)
Vardonikolaki et al. (2021)	Greece	4	Musicians and sound engineers	274	207	37.0 (10.7)
Westmore and Eversden (1981)	United Kingdom	4	Orchestral musicians	34	-	-
Wilson et al. (2013)	Australia	4	Horn players	142	80	-
Zeigelboim et al. (2014)	Brazil	4	Military band members	19	19	33.7 (7.2)
Zeigler and Taylor (2001)	United States	4	Music students	248	94	-
Zuhdi et al. (2020)	United States	4	Classical guitarists	190	159	45.8 (17.6)

Abbreviation: OLE, Oxford Level of Evidence.

objectively, and 90.5% (95% CI: 60.9%-99.7%) were self-reported.

## Discussion

Our systematic review and meta-analysis aimed to describe the prevalence of hearing loss, hyperacusis, and tinnitus among musicians compared to non-musicians. We found that musicians demonstrated a significantly higher prevalence of hearing loss, hyperacusis, and tinnitus compared to non-musicians. Tinnitus was the most frequently reported symptom among musicians, with the majority of cases being occasional rather than permanent (**Table 2**). Nearly 40% of hearing loss cases in musicians were based on objective criteria, unlike in controls, where most cases were self-reported. Notably, there was not a significant difference in the prevalence of auditory symptoms between classical and pop/rock musicians (**Figure 4**).

Our work builds upon a previous systematic review by Di Stadio et al (2018), which explored the prevalence of auditory symptoms among professional musicians.<sup>7</sup> We

combined data from studies including both amateur and professional musicians, allowing us to conduct a more robust meta-analysis. This decision was made for several reasons. First, both groups engage in musical activities that can involve prolonged and repetitive exposure to potentially harmful sound levels, even if the intensity and frequency of exposure differ. For example, while college music students might not meet the criteria of professional musicians, they often experience high noise exposure. Tufts and Skoe (2018) conducted a week-long dosimetry study in college-aged music students and found that 74% of students exceeded the daily exposure limits.<sup>80</sup> Second, many studies did not clearly distinguish between amateur and professional status, or used varying definitions, making strict separation impractical and potentially inconsistent. Third, including both groups allowed for a more comprehensive assessment of auditory symptom prevalence across the broader musician population.

In contrast to Di Stadio et al (2018),<sup>7</sup> who found a significantly higher prevalence of hearing loss and hyperacusis among pop/rock musicians compared to classical musicians, our meta-analysis found no difference

**Table 2.** Risk of Bias Summary for All Cross-Sectional Studies Assessed With Joanna Briggs Institute (JBI) Critical Appraisal Tool<sup>a</sup>

Study (year)	1	2	3	4	5	6	7	8	Overall
Ackermann et al. (2014)	Y	Y	Y	Y	Y	U	Y	Y	7
Alcala Rueda et al. (2023)	Y	Y	Y	N	N	U	Y	Y	5
Barlow (2010)	Y	Y	Y	Y	Y	U	Y	U	6
Barlow (2011)	Y	Y	U	Y	Y	N	Y	U	5
Boissinot et al. (2022)	Y	Y	Y	Y	Y	Y	Y	Y	8
Brar et al. (2023)	Y	Y	U	Y	Y	Y	Y	Y	7
Bray et al. (2004)	Y	Y	Y	Y	U	N	Y	U	5
Callahan et al. (2011)	Y	Y	Y	Y	Y	U	U	U	5
Cândido et al. (2012)	Y	Y	U	Y	Y	N	Y	U	5
Carneiro Muniz et al. (2021)	Y	Y	Y	Y	U	N	Y	Y	6
Chesky and Henoch (2000)	N	Y	Y	N	Y	N	Y	Y	5
Couth et al. (2019)	Y	Y	U	Y	Y	Y	Y	Y	7
Couth et al. (2020)	Y	Y	Y	Y	Y	Y	Y	Y	8
Crawford et al. (2023)	Y	Y	Y	Y	U	N	Y	Y	6
Dance and Zepidou (2024)	Y	Y	Y	Y	U	N	Y	U	5
Dinakaran et al. (2018)	Y	Y	U	Y	Y	N	U	Y	5
Dreyer et al. (2023)	Y	Y	Y	Y	U	N	Y	Y	6
Gopal et al. (2013)	Y	Y	Y	Y	Y	N	Y	Y	7
Gunduz et al. (2022)	Y	Y	Y	Y	N	N	Y	Y	6
Hasson et al. (2009)	Y	Y	Y	U	Y	Y	Y	Y	7
Hoffman et al. (2006)	Y	Y	U	Y	Y	Y	Y	Y	7
Jansen et al. (2009)	Y	Y	Y	Y	N	N	Y	Y	6
Kaharit et al. (2003)	Y	Y	Y	Y	Y	U	Y	Y	7
Laitinen (2005)	Y	Y	Y	Y	N	N	U	Y	5
Laitinen and Poulsen (2008)	Y	Y	Y	U	N	N	Y	Y	5
Luders et al. (2016)	Y	Y	Y	U	Y	N	U	Y	5
Maia and Russo (2008)	Y	Y	Y	Y	N	U	Y	Y	6
McGinnity et al. (2021)	Y	Y	Y	Y	U	U	Y	Y	6
Miller et al. (2007)	Y	Y	Y	Y	U	U	Y	Y	6
Nambiar et al. (2024)	Y	Y	Y	Y	N	U	Y	Y	6
O'Brien et al. (2014)	Y	Y	Y	U	Y	Y	Y	Y	7
Olson et al. (2016)	Y	Y	Y	Y	Y	Y	Y	Y	8
Ostri et al. (1989)	Y	Y	Y	Y	U	U	Y	Y	6
Parra et al. (2018)	Y	Y	Y	Y	Y	Y	Y	Y	8
Pawlaczyk-Łuszczynska et al. (2017)	Y	Y	Y	Y	Y	U	Y	Y	7
Potier et al. (2009)	Y	Y	Y	Y	N	N	Y	Y	6
Pouryaghoub et al. (2017)	Y	Y	Y	U	Y	N	Y	Y	6
Raeburn et al. (2003)	Y	Y	U	Y	Y	U	Y	Y	6
Ramma et al. (2021)	Y	Y	Y	Y	U	N	Y	Y	6
Raymond et al. (2012)	Y	Y	U	U	Y	U	Y	Y	5
Royster et al. (1991)	Y	U	Y	Y	Y	Y	Y	Y	7
Ryan et al. (2023)	Y	Y	Y	Y	Y	N	Y	Y	7
Schmidt et al. (2019)	Y	Y	Y	Y	Y	Y	Y	Y	8
Schmuziger et al. (2006)	Y	Y	Y	Y	Y	U	Y	Y	7
Schurig et al. (2024)	Y	Y	Y	Y	N	N	Y	Y	6
Setiawan and Maryati (2018)	Y	Y	Y	Y	N	N	Y	Y	6
Steurer et al. (1998)	Y	Y	Y	Y	Y	N	Y	Y	7

(continued)

**Table 2.** (continued)

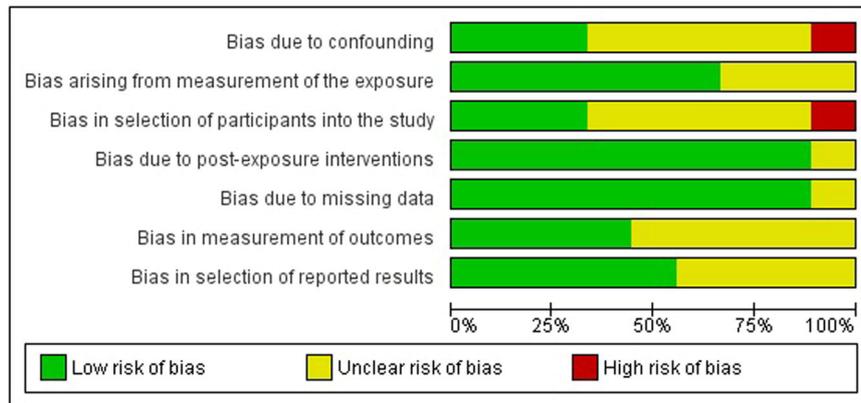
Study (year)	1	2	3	4	5	6	7	8	Overall
Topoglu et al. (2018)	Y	Y	Y	Y	Y	N	Y	Y	7
Toppila et al. (2011)	Y	Y	Y	Y	Y	N	Y	Y	7
Vardonikolaki et al. (2021)	Y	Y	Y	Y	Y	U	Y	Y	7
Westmore and Eversden (1981)	Y	Y	Y	Y	N	N	Y	U	5
Wilson et al. (2013)	Y	Y	Y	Y	Y	Y	Y	Y	8
Zeigelboim et al. (2014)	Y	Y	Y	Y	N	N	Y	Y	6
Zeigler and Taylor (2001)	Y	Y	Y	Y	Y	U	U	U	5
Zuhdi et al. (2020)	Y	Y	Y	Y	N	N	Y	Y	6

Abbreviations: N, no; U, unclear; Y, yes.

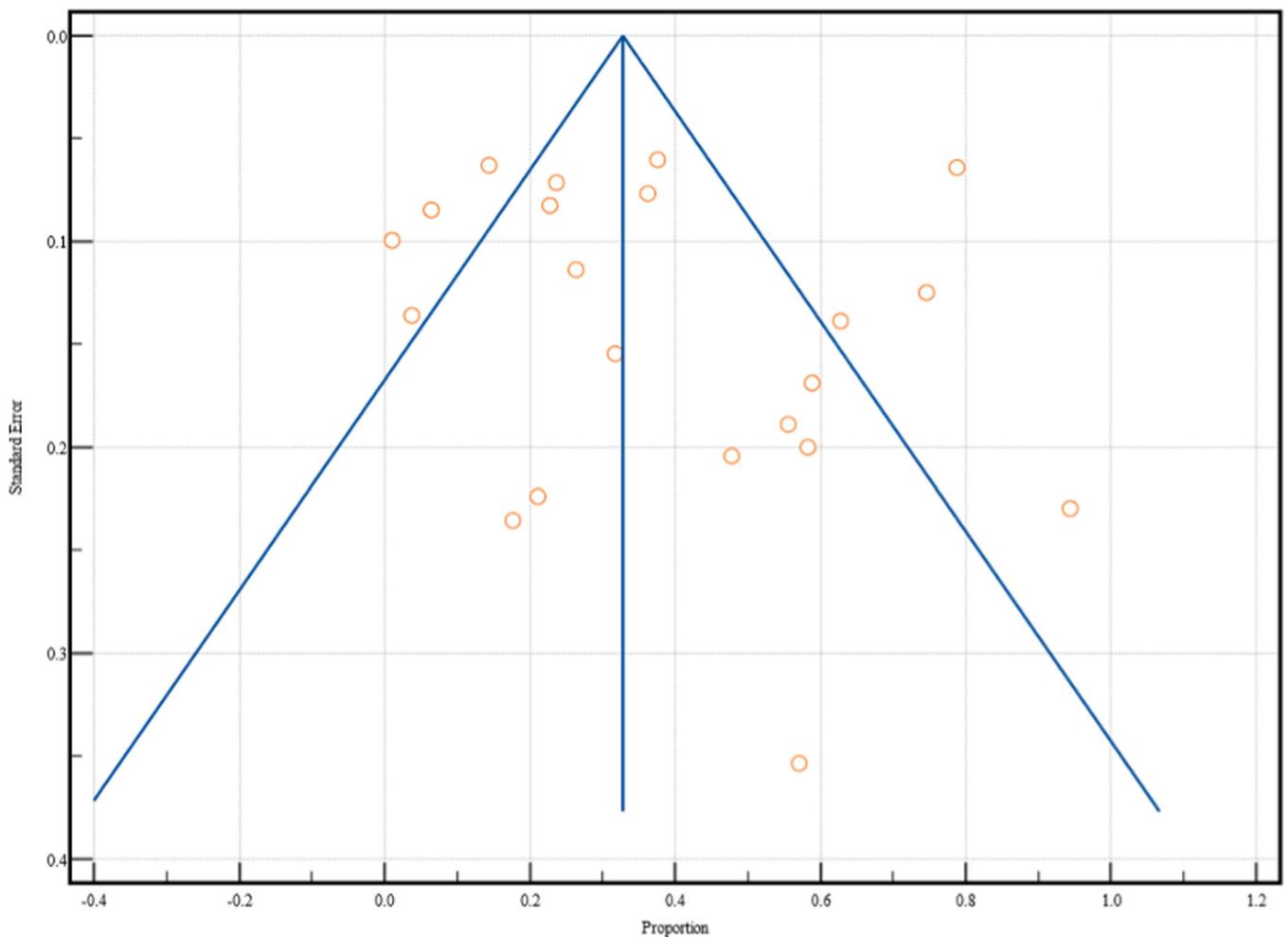
<sup>a</sup>1. Were the criteria for inclusion in the sample clearly defined? 2. Were the study subjects and the setting described in detail? 3. Was the exposure measured in a valid and reliable way? 4. Were objective, standard criteria used for measurement of the condition? 5. Were confounding factors identified? 6. Were strategies to deal with confounding factors stated? 7. Were the outcomes measured in a valid and reliable way? 8. Was appropriate statistical analysis used?

in the prevalence of auditory symptoms between these two groups. This discrepancy could be partly explained by the complex and variable nature of noise exposure in musical settings, which is influenced by multiple factors beyond genre alone. For example, a noise-dosage study has demonstrated that noise exposure levels can vary by ensemble type, musician position, and room acoustics. Musicians seated in the back of ensembles, such as percussionists and brass players, tend to experience higher sound dosages, as do those seated directly in front of louder instruments.<sup>81</sup> In addition, the use of HPDs appears to be increasing in some musical contexts. Among early-career musicians in the United Kingdom, reported HPD use rose from 66.5% in 2018 to 77.5% in 2021.<sup>82,83</sup> The uptake of HPDs could also be increasing in certain genres; for example, attendees of electronic dance music events were particularly likely to use HPDs consistently, citing social media and peer influence as motivators.<sup>84</sup> However, classical musicians often report barriers to HPD use, such as interference with performance and difficulty hearing ensemble members.<sup>42</sup> Together, these findings suggest that individual factors, such as instrument type, positioning, and attitudes towards hearing protection, could play a more critical role in auditory risk than genre alone.

Our review demonstrated that musicians were significantly more likely than the control population to develop hearing loss. Among musicians who reported hearing loss, 63% of cases were based on subjective perception, while only 37% were confirmed through objective testing. Given that individuals with audiometrically determined hearing loss do not always perceive their hearing impairment, reliance on self-report likely underestimates the true prevalence.<sup>85</sup> In a cross-sectional study of 370 professional and 401 amateur musicians, nearly all professionals (97%) had undergone a hearing



**Figure 2.** Risk of bias assessment. Proportions of studies assigned to each risk category for individual bias items are presented, as assessed using the Risk Of Bias In Nonrandomized Studies - of Exposure (ROBINS-E) tool.



**Figure 3.** Funnel plot of studies included for analysis of the overall prevalence of hyperacusis among musicians.

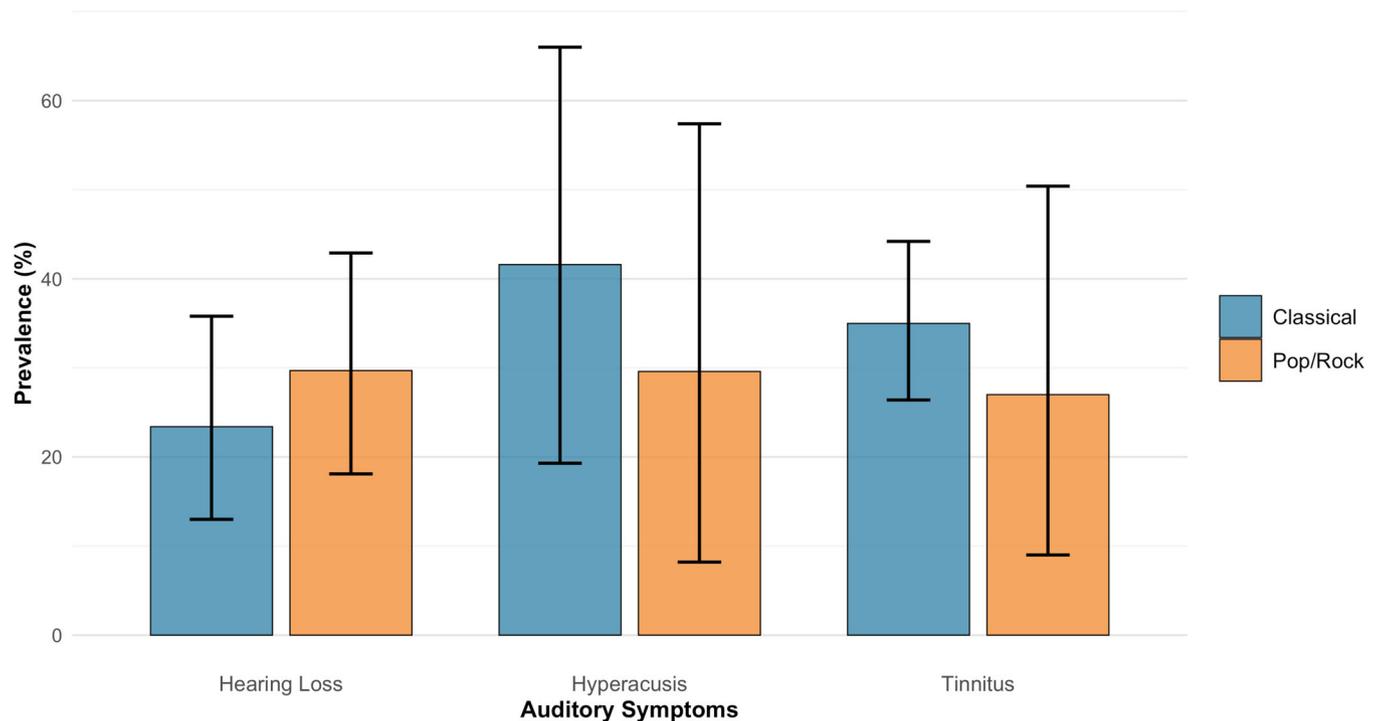
evaluation, compared to only 72% of amateurs. On average, the most recent evaluation occurred 2.7 years ago (SD = 3.8) for professionals and 5.2 years ago (SD = 6.0) for amateurs.<sup>86</sup> Early detection is critical, as even a 10-dB threshold shift at 2000, 3000, and 4000 Hz is considered an early indicator of permanent hearing loss.<sup>87</sup> In some cases, extended high-frequency

audiometry (12-16 kHz) might be warranted, particularly for instruments like the violin, where early noise-induced changes are often more evident at higher frequencies.<sup>36,88</sup> These findings highlight the importance of individualized audiologic monitoring, with hearing assessments tailored to the specific exposure patterns and risks associated with each instrument.

**Table 3.** Prevalence of Auditory Symptoms Among Musicians Compared to the Control Population

Symptom	Musician:control (n)	Prevalence (95% CI) among musicians	Prevalence (95% CI) among control population	P-value for comparison of proportions
Hearing loss	15,602:3,340,846	25.7% (21.0%-30.6%)	11.6% (6.5%-18.1%)	$P < .0001$
Hyperacusis	1964:114	37.3% (25.5%-49.9%)	15.3% (9.3%-23.2%)	$P < .0001$
Tinnitus	7570:3,340,866	42.6% (34.6%-50.7%)	13.2% (0.5%-38.7%)	$P < .0001$

### Prevalence of Auditory Symptoms by Music Genre

**Figure 4.** Proportion of classical and pop/rock musicians experiencing hearing loss, hyperacusis, and tinnitus, respectively. Error bars represent the 95% confidence interval.

The prevalence of tinnitus was also significantly higher among musicians compared to the control population. The etiology of tinnitus is not well understood, but risk factors include noise exposure and age-related hearing loss.<sup>89</sup> Although tinnitus is associated with noise-induced hearing loss, its severity correlates with total sound exposure rather than audiometric thresholds alone.<sup>65</sup> Notably, a significant subset of patients with tinnitus or hyperacusis have normal hearing thresholds,<sup>90</sup> suggesting that early cochlear damage can occur without detectable hearing loss and contribute to tinnitus or hyperacusis.<sup>91</sup> Furthermore, an audiometric study of patients with hyperacusis found reduced loudness discomfort levels across all tested frequencies, regardless of the pattern or degree of hearing loss, suggesting that hyperacusis could reflect central auditory gain rather than hearing loss itself.<sup>92</sup> These findings suggest that tinnitus and hyperacusis could arise from early auditory dysfunction not captured by standard

audiometry, emphasizing the importance of routine auditory screening and monitoring for musicians, particularly those with high exposure to sound.

#### Limitations and Future Directions

Our meta-analysis was limited by heterogeneity in genre, setting, instrument played, and length of exposure. Additionally, most studies did not assess confounding factors such as leisure noise exposure, age, preexisting medical conditions, and use of hearing protection. Another limitation lies in potential underreporting of musician status, as many amateur or part-time musicians might primarily identify by their main occupation rather than as musicians, leading to possible misclassification bias in the included studies. Furthermore, there was a lack of consistency in subjective versus objective reports of hearing loss. The majority of symptoms, particularly

tinnitus and hyperacusis, were self-reported, which is susceptible to recall bias and reporting bias. Finally, exposure to other sources of music, such as frequent headphone or speaker use, might further confound the relationship between musicianship and hearing outcomes but could not be adequately controlled for in this analysis. Future research could aim to provide an individualized risk assessment for musicians by exploring factors such as instrument type, performance setting, and additional sources of auditory exposure.

## Conclusion

Our meta-analysis found that musicians experience significantly higher rates of hearing loss, hyperacusis, and tinnitus than non-musicians, with tinnitus being the most common symptom. At least one in three musicians reports tinnitus or hyperacusis, while approximately one in four has hearing loss. Symptom prevalence did not differ between classical and pop/rock musicians, highlighting that risk extends across genres. These findings are relevant for otolaryngologists, who play an important role in identifying early signs of auditory dysfunction. Tailored strategies, including regular auditory assessments, education on safe listening practices, and guidance regarding instrument- or performance-specific risk factors, might help reduce the burden of auditory symptoms in this high-risk population.

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The authors have nothing to report.

## Author Contributions

**Lauren R. McCray:** Conception/design, data acquisition, data analysis, manuscript preparation; **Asher T. Ripp:** Conception/design, data acquisition, data analysis, manuscript preparation; **Shaun A. Nguyen:** Data analysis, software and tools, manuscript preparation; **Justin C. Pelic:** Data acquisition, manuscript preparation; **Robert F. Labadie:** Manuscript preparation, critical revision; **Ted A. Meyer:** Manuscript preparation, critical revision.

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## Supplemental Material

Additional supporting information is available in the online version of the article.

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