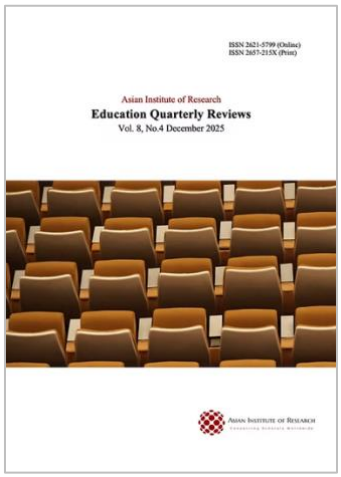

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Rehearsal Musical Sound and Hearing Health: The Case of Church Instrumentalists

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Abstract
Background: Musicians are at risk for noise-induced heearing loss (NIHL) due to their repeated exposure to loud sound levels without hearing protection. However, limited literature exists regarding the hearing health of student musicians in Ghana. Objective: This study assessed hearing thresholds and sound exposure levels during rehearsals of University of Education, Winneba (UEW) church instumentalists (music students) and compared them with age-matched non-music peers. Methods: A cross-sectional descriptive survey was employed involving twenty participants aged 18 to 25 years, comprising 10 students who did not play music and another 10 music students took part. A structured questionnaire (case history), an AD 27 diagnostic audiometer for pure tone hearing thresholds, a Madsen tympanometer for middle ear status, and a Kamplex KM-2 Mini sound level meter for rehearsal sound assessment were used to gather data. Results: Average rehearsal sound levels among music students ranged from 93–103 dBA with peaks up to 110 dBA. Four music students exhibited notches at 6000 Hz (≥25 dB HL), indicative of early NIHL, while none of the controls did. Tympanometry results were normal for all. Conclusion: Early indicators of NIHL are seen in church instrumentalists who are subjected to high sound levels. There is the need for preventive hearing conservation programmes in Ghanaian music training environments.

Keywords: Noise-Induced Hearing Loss, Music Students, Sound Exposure, Audiometry

1. Introduction

Noise is an inescapable companent of contemporary life, and prolong exposure to high sound levels, including music, can lead to noise-induced hearing loss (NIHL) (Auchter & Le Prell, 2014; Comeau et al., 2018; World Health Organization, 2021, 2022). For the musician, exposure to loud sounds/noise is a constant aspect of their working environment, often occurring for several hours, which places them at particular risk of developing NIHL (Auchter & Le Prell, 2014; Comeau et al., 2018). Accordingly, NIHL is widely recognized as an occupational health hazard for the performing arts.

International research suggests that pre-professional music students are frequently exposed to elevated sound levels during rehearsals, performance practice, and ensemble performance sessions, sometimes exceeding

occupational safety benchmarks (Auchter & Le Prell, 2014; Phillips et al., 2010). Such consistent exposure can have detrimental effects on their hearing health, including hearing loss.

Several studies conducted in Europe and North America report that pre-professional music students often experience sound exposure levels exceeding occupational safety limits, with approximately 33–52% showing audiometric signatures consistent with NIHL - particularly a characteristic notch around 6000 Hz (Auchter & Le Prell, 2014; Barton, 2021; Chesky, 2011; Comeau et al., 2018; Cook-Cunningham et al., 2012; Farmer et al., 2014; Firle & Richter, 2025; Phillips et al., 2010; World Health Organization, 2022). These findings underscore the need to quantify rehearsal exposure and monitor early auditory changes in training contexts.

Despite these international findings, empirical research on the rehearsal sound exposure and hearing health among student musicians in Ghana remains sparse. As music education becomes more increasingly prominent in universities and churches, this lack of evidence poses a risk to the long-term hearing health of young musicians.

In Winneba and similar urban Ghanaian settings, university music students often serve as instrumentalists in both Pentecostal/Charismatic and mainline churches. Typically, rehearsals are held in multipurpose halls or sanctuaries with minimal acoustic treatment, and reflective surfaces like tiles, concrete, or glass. Typical instrumentation includes drum, electric bass, and guitars via amplifiers, digital keyboards, brass/woodwinds, and a public-address system with wedge or in-ear monitoring. Schedules cluster around mid-week and weekend services (roughly 2 - 4 sessions per week, 90 - 180 minutes per session), with close spacing between players and speaker stacks. Regular sound-level monitoring and the usage of hearing protection devices are rare in church settings. Exposure heterogeneity by instrument and on-stage position is shaped by these contextual characteristics, which presumably increase rehearsal sound exposure levels.

This study examines the exposure to rehearsal sounds and hearing status of church instrumentalists who are University of Education, Winneba (UEW) music students compared to their age-matched non-music peers. The study examines potential factors such years of playing, instrument family, rehearsal-room features, proximity to loudspeakers, and use of hearing protection in addition to comparing exposure to recognised occupational benchmarks (time-weighted averages and peak criteria).

2. Methods

The study adopted a descriptive cross-sectional design to investigate the hearing sensitivity and noise exposure levels of student church instrumentalists compared with age-matched non-music peers at the UEW, which included twenty (20) undergraduate students aged 18 and 25 years. Participants comprised of ten (10) Level 200 music students (music group) who serve as instrumentalists in various campus-based churches (percussion, string, and wind instruments) and ten (10) age-matched non-music students from other departments who were not engaged in regular musical activities. To be included in the study, participants for the music group must be student church instrumentalists, should have no self-reported history of chronic ear infection or diagnosed hearing loss and be willing to participate and sign an informed consent with the purpose and procedures explained. The study was conducted at the Centre for Hearing and Speech Service (CHSS), and selected rehearsal rooms used by the music departments at UEW, Winneba. Audiometric and tympanometric assessments were performed on each participant in a soundproof room at the CHSS to establish participants' hearing sensitivity, while sound level measurements were taken in participants' rehearsal environments.

A case history form from CHSS was used to collect data on participants' demographics, musical background, noise exposure history, and self-reported auditory symptoms. Real-time sound pressure levels (SPLs) during 60-minute rehearsal sessions were measured using a Kamplex KM-2 Mini sound level meter. Pure-tone hearing thresholds were obtained with an AD 27 diagnostic audiometer fitted with TDH-39 supra-aural headphones, while a Madsen tympanometer was used to assess middle ear function and rule out pathology prior to audiometric testing.

Prior to data collection, all participants underwent an otoscopic examination to screen for and rule out any external ear canal obstruction or pathology. Following this initial screening, participants completed the case history form

under the supervision of the researcher to ensure accuracy and completeness of responses. This questionnaire gathered information on demographic characteristics, musical background, history of noise exposure, and self-reported auditory symptoms such as tinnitus or temporary threshold shifts. For music participants, sound level measurements were then conducted during their typical rehearsal sessions using a Kamplex KM-2 Mini sound level meter, with continuous recordings taken over a 60-minute period to capture both average equivalent continuous sound levels (Leq) and peak maximum levels (Lmax).

After a rest period of approximately 12 hours following their last rehearsal, pure-tone audiometric assessments were conducted in a sound-treated booth using an AD 27 diagnostic audiometer with TDH-39 supra-aural headphones, employing the modified Hughson-Westlake method (10 dB down, 5 dB up) to establish hearing thresholds at octave and inter-octave frequencies of 250, 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz. Finally, tympanometry was performed using a Madsen tympanometer to evaluate the condition of the middle ear system and confirm normal middle ear function, indicated by Type A tympanograms, before interpreting the audiometric results.

3. Results

The demographic data show that both groups were well-matched in age (mean 20.6 years for music students and 20.2 years for non-music controls) and gender distribution (8 males and 2 females in the music group; 6 males and 4 females in the control group), ensuring comparability between the groups and reducing confounding due to age or sex (Table 1).

Table 1: Participant's demographics

Group	N	Mean Age (years)	Male	Female
Music students	10	20.6	8	2
Non-music controls	10	20.2	6	4

Rehearsal sound level measurements revealed that the music students were exposed to **very high sound pressure levels (SPLs),** with average levels ranging from **93 to 103 dBA** and **peak levels up to 110 dBA.** The calculated mean average SPL was **97.9 dBA (SD ±3.7),** well above the recommended safe exposure limit of 85 dBA for an 8-hour workday (Table 2). The longest daily exposure durations were recorded among percussion (180 minutes) and wind instrument players (up to 150 minutes), indicating prolonged and potentially hazardous noise exposure patterns.

Table 2: Rehearsal time for participants

Participant	Instrument	Avg SPL (dBA)	Peak SPL (dBA)	Duration (mins/day)
M1	Drums (Percussion)	101	108	180
M2	Bass Guitar (Strings)	97	104	150
M3	Electric Guitar (Strings)	95	100	120
M4	Keyboard	93	98	90
M5	Trumpet (Wind)	103	110	120
M6	Saxophone (Wind)	100	107	150
M7	Drums	102	109	180
M8	Acoustic Guitar	94	98	90
M9	Keyboard	93	96	120
M10	Drums (Percussion)	101	106	150

Mean average SPL: 97.9 dBA (SD ±3.7)
Peak SPL range: 96–110 dBA

Audiometric findings showed that music students had **elevated thresholds at higher frequencies,** particularly at **6000 Hz, where the average was 28 dB HL** compared to **14 dB HL in controls (Table 3)**. Notably, **four of the ten music students demonstrated a noise notch (≥25 dB HL) at 6000 Hz,** a classic early marker of noise-induced hearing loss (NIHL), while none of the control group showed such notches. At other frequencies (1000 - 4000 Hz, 8000 Hz), both groups showed thresholds within the clinically normal range (<25 dB HL), though music students tended to have slightly higher values.

Table 3: Average hearing thresholds of participants across tested frequencies

Group	250 Hz	500 Hz	1000 Hz	2000 Hz	3000 Hz	4000 Hz	6000 Hz	8000 Hz
Music (avg. dB HL)	14	13	13	14	13	17	28	19
Control (avg dB HL)	11	9	9	10	8	10	8	15

Tympanometry confirmed **normal middle ear status (Type A tympanograms)** across all participants, which rules out conductive pathology as a cause of the elevated high-frequency thresholds. Additionally, **8 out of 10 music students reported experiencing tinnitus following rehearsals,** further suggesting temporary auditory stress, while only 2 of the non-music peers reported occasional loud recreational noise exposure.

4. Discussion

This study assessed hearing thresholds and sound exposure levels during rehearsals of University of Education, Winneba (UEW) church instumentalists (music students) and compared them with age-matched non-music peers. The study provides preliminary evidence that student church instrumentalists at UEW are regularly exposed to hazardous sound levels and already exhibit early audiometric signs consistent with noise-induced hearing loss (NIHL). Average rehearsal levels approached ~98 dBA with peaks up to 110 dBA, far exceeding widely accepted occupational guidelines for safe exposure. These exposure profiles dovetail with international literature documenting elevated risks among pre-professional musicians who rehearse and perform in high-level sound environments as a routine condition of study and work (Auchter & Le Prell, 2014; Firle & Richter, 2025; Kornisch et al., 2023; Phillips et al., 2010). Consistent with those reports, 40% of the instrumentalists in our sample showed a high-frequency notch at 6000 Hz (≥25 dB HL) - a classic early marker of NIHL - whereas none of the age-matched non-music peers demonstrated this pattern (Maas, 2019; Phillips et al., 2010).

The frequency-specific elevation at 6000 Hz in the music group, accompanied by normal tympanograms for all participants, supports a predominantly cochlear (sensorineural) origin rather than middle-ear involvement. This aligns with established mechanisms of NIHL in which outer hair cells in the basal turn of the cochlea are particularly vulnerable to sustained and/or impulsive sound exposure (Farmer et al., 2014; Hawkins, 2013). The high prevalence of post-rehearsal tinnitus among instrumentalists (8/10) further suggests temporary auditory stress and is concordant with prior studies that identify tinnitus as an early warning sign of excessive exposure among young musicians (Comeau et al., 2018; Firle & Richter, 2025; Phillips et al., 2010). Notably, the instruments associated with the highest average and peak SPLs in our cohort - percussion and brass/wind - mirror patterns observed elsewhere, where percussionists and brass players often experience the greatest on-stage exposure due to instrument directivity and proximity (Chasin Marshall, 2010; Maas, 2019).

Although mean thresholds for most test frequencies remained within the clinically “normal” range (<25 dB HL), between-group differences at the higher frequencies (particularly 6000 Hz) underline the importance of including inter-octave testing (3000 and 6000 Hz) in screening protocols for music populations. These data also reinforce the point that “normal” audiograms can mask emerging, exposure-related changes in the high frequencies among young adults who are early in their training trajectories. In the Ghanaian context - where formal hearing conservation practices within tertiary music and church settings are not yet routine - the findings fill an important evidence gap and underscore the urgency of structured prevention efforts.

The study's practical implications imply that hearing conservation measures ought to be incorporated into music programmes. Environmental measures like sound treatment in the rehearsal room and ensemble spacing, education on safe listening techniques and the dangers of cumulative noise exposure, regular access to flat-attenuation musician earplugs, and planned audiologic monitoring to identify early changes are a few examples. International research involving student musicians has suggested that normalising protective behaviours can be achieved by incorporating these measures into ensemble policies and curricula (Phillips et al., 2010).

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