

Occupational Noise Exposure and Audiometric Abnormalities among Traffic Enforcers in Cebu City: A Descriptive Correlational Study

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ABSTRACT

This study investigated the association between occupational noise exposure levels (ONEL) and auditory health among traffic enforcers in Cebu City, Philippines. Using a descriptive-correlational research design, the study involved 56 traffic enforcers who were categorized based on high or low levels of noise exposure. Data were gathered through structured health history questionnaires and audiometric testing via Pure Tone Audiometry (PTA). Results revealed that ONEL had a statistically significant association with hearing thresholds at 8000 Hz ($p = 0.027$), indicating high-frequency hearing loss among those exposed to elevated noise levels. However, no significant associations were observed at lower frequencies. Notably, age ($p = 0.013$ right ear; $p = 0.012$ left ear) and self-reported hearing-related health outcomes ($p = 0.015$ right ear; $p = 0.011$ left ear) were significantly associated with PTA results, suggesting that hearing loss may also be influenced by age-related factors and underlying health conditions. Other variables—including smoking status, alcohol use, and exposure to recreational noise—showed no significant correlation with either ONEL or hearing thresholds. These findings underscore the multifactorial nature of occupational hearing loss and emphasize the need for targeted health surveillance, regular audiometric screening, and preventive hearing conservation programs tailored to the specific risks faced by traffic enforcers.

Keywords: *occupational noise, hearing loss, traffic enforcers, Cebu City, noise-induced hearing loss, audiometry, public health, environmental noise*

INTRODUCTION

Workplaces in urban areas today face an ongoing and often understated danger from exposure to occupational sound. The effects of noise on health are one of the most widespread physical agents in rapidly urbanizing areas, where traffic congestion and infrastructure limitations often exacerbate ambient sound levels. A range of health outcomes, including severe sensorineural hearing loss due to chronic exposure to high-intensity noise, cardiovascular strain, sleep disturbances and reduced occupational performance, have been associated with this. The work of traffic enforcement is characterized by their frequent assignment in noisy environments like busy intersections, terminals and roadside corridors. OSHA (OSHA, 2023) has established a noise exposure limit of 85 decibels A-weighted (dBA) for an 8-hour workday that is frequently exceeded in these locations. Traffic enforcers are still not well-documented in occupational health literature, especially in Southeast Asian countries like the Philippines where urbanization is on the rise and noise regulation enforcement is inadequate. Around 16% of hearing loss in adults worldwide is believed to be caused by occupational noise (WHO, 2018).. Chronic exposure to urban traffic noise has been found to be the cause of high rates of noise-induced hearing loss (NIHL) in traffic police officers in developing countries such as India, Brazil, and Bangladesh (Jeyakumar & Subramanian, 2021; Lopes et al, 2020; Islam a. 2021). In the Philippines, there are few publications that focus solely on public safety personnel working in the streets, such as traffic stoppers, due to geographical

limitations and limited research. Occupational health policies that are responsive to urban enforcement work are hindered by the absence of localized data. This is problematic.

A rapidly developing metropolitan area in the Visayas region, Cebu City provides a compelling setting for research on occupational noise exposure. Despite the lack of significant noise management improvements, the city has seen a notable surge in motor vehicle traffic. As a result, ambient noise levels in high-traffic areas frequently surpass both national and international occupational safety standards (DENR-EMB], 2020). In Cebu City, the absence of audiometric evaluations and PPE provision has led to concerns about occupational health and regulatory oversight.

The most reliable method for assessing auditory function in exposed individuals is Pure Tone Audiometry (PTA), which remains the gold standard. The hearing sensitivity of an individual is measured by PTA using various frequencies, with a range typically starting at around 250. Hz to 8000. Early indications of NIHL, commonly known as high-frequency hearing threshold shifts, require the detection of frequencies above 100 Hz. This test gives objective and measurable information to help identify both temporary hearing impairments and permanent hearing loss. PTA plays a crucial role in occupational health surveillance by assessing the cumulative effects of noise exposure and providing guidance on adopting preventive measures. Despite its effectiveness, PTA is not widely used by public sector employees in the Philippines, especially those working as traffic enforcement agents.

Prolonged exposure to excessive sound pressure levels is responsible for the pathophysiology of NIHL, which involves the gradual decline of cochlear hair cells and auditory nerve pathways. Risk factors such as age, biological sex, comorbidities (such as hypertension and diabetes mellitus), smoking, and alcohol use have been identified as potential contributors to auditory damage. Liu et al, (2021) suggested that age-related cochlear decline may have a potentiating effect on NIHL, while Nomura (2005) and Gopinath (2009) found that the use of tobacco and alcohol hinders the supply of cochyles and hinderd the processing of central auditory functions.

The impact of occupational noise and health effects is gaining global attention, but there's a significant gap in research on the relationship between these variables and urban environments in Philippines. Recent studies by David and Custodio (2020) in Davao City and Ong et al. (2023) have attempted to address these issues, but no comprehensive research has been conducted in Cebu City.

To address this inadequacy, this study will conduct a systematic analysis of the frequency of occupational noise exposure among traffic enforcers in Cebu City and examine its correlation with audiometric findings using pure tone audiometry. Additionally, it seeks to explore the impact of demographic traits, comorbid medical conditions, and behavioral risk factors on hearing status.

This study generates localized empirical data that contributes to a better understanding of occupational hazards faced by traffic enforcers and helps develop specific health surveillance protocols and preventive occupational safety policies. The aim of the

research is to support public health promotion by presenting evidence-based plans that safeguard urban residents from environmental noise exposure.

REVIEW OF LITERATURE

In industries with high acoustic environments, there has been extensive research on occupational noise exposure. Studies indicate that both auditory and systemic health effects are linked to long-term noise exposure. The authors of the study, Basner et al. (2014), have suggested that prolonged exposure to noise levels above safe thresholds can result in tinnitus (TBS), temporary or permanent threshold shifts, and irreversible hearing loss (IHL). In addition to auditory dysfunction, chronic exposure to noise has been associated with other non-auditory health consequences including: elevated blood pressure, hypertension, heart disease, and stress. In order to reduce the risk of NIHL, both the World Health Organization (2018) and OSHA (2023) have established an occupational exposure limit of 85 dBA over an 8-hour time-weighted average. However, urban areas with dense infrastructure and limited regulations often exceed these boundaries, particularly in developing nations. This is especially true for road construction projects. Nevertheless, The exposure of individuals like traffic cops to high-profile noise areas makes them particularly vulnerable in these situations. Why?

In terms of biology, NIHL is defined as damage to the outer hair cells of the cochlea, leading directly to increased auditory thresholds, particularly at high frequencies (Clark et al, 2019). The damage may eventually reach inner hair cells and spiral

ganglion neurons, which can interfere with sound discrimination and auditory processing. The primary diagnostic approach for early and progressive hearing loss is Pure Tone Audiometry (PTA). The evaluation of hearing sensitivity across standard frequencies by PTA is crucial for occupational health monitoring, as it allows for the identification of affected frequencies and the measurement of severity. Multiple studies have shown that exposure to the full range of sounds can lead to hearing loss. According to Seixas et al. (2005 work), workers who have been exposed to occupational noise for more than 10 years have experienced significant threshold changes, with the most prominent shift occurring in zones 3000–6000. Hz range. Traffic enforcers at intersections with high traffic density experienced more severe sound damage, as noted by Jeyakumar and Subramanian (2021). According to Lopes et al. (2020) and Islam a.z. (2021), Bangladesh has reported similar findings that indicate prolonged exposure to urban traffic noise is primarily causing the risk of death caused by NIHL.

The findings are backed up by local studies. Those assigned to high-traffic locations in Metro Manila were found to have hearing profiles with higher thresholds at higher frequencies by Ong et al. (2023). Over 60% of those surveyed by David and Custodio (2020) revealed that they had early indications of hearing loss. Hypertension, diabetes, and the absence of hearing protection devices were among the risk factors associated with these findings. These conditions are commonly found in urban occupational groups that receive inadequate hearing aids.

It has been extensively documented that systemic health conditions have an impact on the auditory outcomes. Environmental noise was identified by Foraster et al. (2014) and Buell remarked (2020) as a potential reason for the increase in cochlear function, which can be associated with hypertension and metabolic disturbances. As a result, Horikawa et al. (2013) stated that diabetes mellitus can interfere with cochlear microcirculation (see below) and thus increase the risk of ischemic damage to the structures of the inner ear.

Moreover, occupational noise exposure can be intensified by lifestyle factors like alcohol and tobacco use. These findings are not universal. The ear's ability to resist acoustic trauma is reduced by smoking, which results in vasoconstriction of the cochlear blood supply, as noted by Nomura et al. (2005). This can lead to hypoallergenicity. According to Gopinath et al. (2010), excessive alcohol consumption may impair auditory neurotransmission and potentially contribute to central auditory processing deficits. The likelihood and severity of NIHL are significantly increased by the compounding effect of behavioral risk factors and occupational exposure. Although there are many references in literature, gaps persist, particularly in the Philippine context. Occupational health studies in the country tend to focus on industrial workers, while public sector workers like traffic enforcement are relatively unstudied. Additionally, audiometric results are not as easily integrated with demographic, medical, and behavioral data in these studies. Lack of systematic monitoring and preventive measures further aggravates the vulnerability of this occupational group.

Localized, interdisciplinary research that investigates the complex interplay between noise exposure and hearing status is essential in understanding health-related risk factors. This paper highlights these findings. In order to meet that demand, this research employs pure tone audiometry to evaluate auditory function and analyzing demographic data along with medical and lifestyle variables among traffic stoppers in Cebu City. Its objective is to provide a comprehensive and evidence-based understanding of the risks associated with occupational noise in an urban environment in the Philippines.

Need of the study

Despite growing evidence that traffic enforcers are exposed to hazardous levels of environmental noise, there remains a lack of comprehensive and localized data on the auditory health status of this workforce, particularly in Cebu City. Most existing occupational health assessments focus on industrial or manufacturing workers, leaving a significant research gap in public service occupations such as traffic enforcement. This study is especially relevant in the context of rapidly urbanizing Philippine cities where vehicular congestion, inadequate enforcement of environmental noise regulations, and limited access to hearing protection converge to increase health risks among frontliners.

The significance of this study lies in its ability to provide empirical data on the occurrence of occupational noise and its associations with demographic characteristics, comorbid conditions, lifestyle habits, and physiological outcomes such as audiometric profiles. It will help build a nuanced understanding of how

multiple risk factors interact in real-world urban settings.

Findings from this study are expected to: (1) inform the development and implementation of health and safety protocols tailored to traffic enforcers, (2) support policy advocacy for the institutionalization of routine audiometric screening and provision of personal protective equipment (PPE), (3) assist local government units and public health agencies in creating evidence-based, preventive occupational health programs, and (4) enrich the national and regional body of literature on urban noise exposure by offering localized insights rooted in interdisciplinary data.

Ultimately, this research aims not only to improve working conditions for Cebu City's traffic enforcers but also to contribute toward building a broader framework of environmental justice and public health protection for urban workers across developing cities.

METHOD

Aim of the study

This study aims to determine the association between occupational noise exposure and hearing abnormalities among traffic enforcers in Cebu City. Specifically, it investigates whether traffic enforcers assigned to high-noise areas—where average sound levels exceed 85 dBA—present pure-tone audiometry abnormalities. It also explores how demographic, occupational, lifestyle, and health-related factors such as age, sex, years in service, comorbidities, smoking, and alcohol use influence the risk of noise-induced hearing loss (NIHL).

This study employed a descriptive correlational research design to examine the association between occupational noise exposure and hearing abnormalities among traffic enforcers in Cebu City. This design was selected to capture the natural relationships between variables without manipulating the study environment or implementing experimental controls (Polit & Beck, 2021). Specifically, the design enabled the researcher to measure existing conditions—namely, noise exposure levels and hearing thresholds—while also analyzing the influence of demographic, health-related, and occupational variables such as age, sex, years in service, assigned location, comorbidities, and lifestyle factors.

Descriptive correlational studies are appropriate for research involving public health surveillance and occupational risk assessment, particularly when investigating slow-onset conditions like noise-induced hearing loss (NIHL), which develop over prolonged exposure periods (Creswell & Creswell, 2018; Brink & van der Walt, 2020). By capturing data from traffic enforcers in their actual work settings and correlating it with objective audiometric and environmental measurements, the design allowed for a holistic understanding of the burden of occupational noise exposure in this population. Furthermore, this design is useful when ethical or logistical limitations prevent experimental manipulation, especially in field-based occupational health studies (Parahoo, 2014).

The variables examined in this study included the independent variable—occupational noise exposure (categorized as high or low based on time-weighted average decibel levels)—and the dependent variable, hearing status, measured through pure-tone

audiometry. The inclusion of potential confounders and effect modifiers such as comorbidities, lifestyle habits, and work history enhanced the reliability of the findings and allowed for meaningful statistical modeling of associations.

Inclusion criteria

Participants were classified into high or low noise exposure groups based on an 8-hour time-weighted average (TWA) of 85 dBA, consistent with WHO (2018) and OSHA (2023) standards for occupational noise.

Participants must meet the following criteria to be included in the study: (1) currently employed as traffic enforcers by the Cebu City Transportation Office (CCTO), City Traffic Management System (CTMS), or Traffic Enforcement Agency of Mandaue (TEAM), (2) aged between 25 and 65 years old, (3) have at least five consecutive years of continuous service in traffic enforcement, (4) assigned to either a high-noise area (e.g., Osmeña Boulevard, Colon Street, SRP) or a low-noise area (e.g., secondary roads), (5) provide informed written consent to participate, and (6) available to wear a noise dosimeter for an entire 8-hour shift and complete a full audiometric assessment.

Exclusion criteria

Participants will be excluded from the study if they present with any of the following: (1) pre-existing hearing loss documented prior to traffic enforcement employment, (2) chronic or recurrent ear infections, (3) conductive hearing pathologies or middle ear disease, (4) history of ototoxic medication usage, (5) prior employment in other high-noise occupations unrelated to traffic enforcement (e.g., construction,

manufacturing), (6) failure to observe a 16-hour auditory rest period before audiometry, and (7) incomplete audiometric data or noise exposure monitoring.

Procedure

This study utilized a descriptive correlational design to assess the association between occupational noise exposure and hearing abnormalities among traffic enforcers in Cebu City. Recruitment was conducted through stratified random sampling from the rosters of three major traffic enforcement agencies: the Cebu City Transportation Office (CCTO), the City Traffic Management System (CTMS), and the Traffic Enforcement Agency of Mandaue (TEAM). Eligible participants—aged 25 to 65 years and with a minimum of five years of continuous service—were invited to participate following an initial eligibility screening and the provision of written informed consent.

Data collection was implemented over a three- to four-month period and included three primary phases: environmental noise exposure measurement, audiometric assessment, and completion of a structured survey. Noise exposure levels were measured using calibrated personal noise dosimeters worn by participants during a complete 8-hour work shift. These devices recorded ambient sound levels every 10 minutes, and their operation was periodically monitored by trained research staff to ensure data integrity. Exposure levels were categorized as high if the 8-hour time-weighted average (TWA) exceeded 85 decibels A-weighted (dBA), and low if the TWA remained at or below this threshold.

Following noise monitoring, participants underwent pure-tone audiometry conducted by certified audiologists in a sound-treated environment where ambient noise did not exceed 55 dBA. Testing covered standard frequencies (500 Hz, 1,000 Hz, 2,000 Hz, 4,000 Hz, 6,000 Hz, and 8,000 Hz) for both ears. Prior to testing, participants observed at least 16 hours of auditory rest to eliminate temporary threshold shifts. Audiometric thresholds were deemed abnormal if they were equal to or greater than 35 dB in at least one ear at any tested frequency. Hearing loss was classified according to World Health Organization (WHO) criteria, defined as a pure-tone average (PTA) of ≥ 35 dB across 500 Hz to 4,000 Hz in the worse ear.

In addition to the audiological evaluation, participants completed a structured data form collecting information on demographic variables (age, sex, educational attainment), occupational history (years of service, deployment location), lifestyle factors (smoking, alcohol consumption, recreational noise exposure), use of hearing protection devices, and medical history including comorbidities such as hypertension and diabetes. Information on their mode of transportation to and from work was also recorded as a potential secondary source of environmental noise exposure. This multi-modal data collection approach ensured a comprehensive understanding of both occupational and individual risk factors associated with noise-induced hearing loss in this specific urban working population.

All data will be handled according to the Philippine Data Privacy Act of 2012 (RA 10173). Participant identities will be anonymized. Only authorized staff will have access to sensitive data, which will be securely stored and eventually destroyed

according to ethical data retention guidelines. Participants may withdraw at any time.

Analysis

Descriptive statistics were computed to summarize the characteristics of the study population, including demographic variables (age, sex, years of service), health-related factors (hypertension, diabetes, BMI), lifestyle behaviors (smoking and alcohol consumption), and environmental factors (assigned work location, transportation mode). Measures of central tendency (mean, median) and dispersion (standard deviation, range) were used for continuous variables, while categorical variables were presented using frequencies and percentages. These summaries provided a clear profile of the participants and contextualized the prevalence of noise exposure and hearing abnormalities in the population (Creswell & Creswell, 2018).

To determine the association between categorical variables—such as occupational noise exposure levels (high vs. low) and the presence or absence of pure-tone audiometry abnormalities—Pearson's Chi-Square (χ^2) test was employed. This nonparametric statistical test is widely used to evaluate whether a statistically significant relationship exists between two nominal or ordinal variables (Field, 2018). Associations were considered significant at a p-value of less than 0.05. Where applicable, Cramer's V was used to assess the strength of association between variables with more than two categories (Pallant, 2020).

Furthermore, bivariate correlations between continuous predictors (e.g., years of service, BMI) and the dependent variable were

assessed when appropriate, to identify patterns that could inform future multivariate analysis. The use of the Chi-Square test allowed for an appropriate, assumption-free analysis of the categorical data commonly observed in public health and occupational studies (Polit & Beck, 2021). All statistical analyses were conducted using Jamovi.

RESULTS

The demographic and health-related characteristics of the 56 study participants revealed that the majority (82.1%) were exposed to high levels of occupational noise (ONEL), while only 17.9% had lower exposure (see Table 1.). The participants had a mean age of 44.8 years (SD = 9.0), with the low ONEL group being slightly older on average (47.9 years) than the high ONEL group (44.0 years). Almost all participants were male (98.2%), a distribution reflective of the male-dominated nature of traffic enforcement roles in the Philippines.

Regarding health conditions, over half of the total sample reported hypertension (55.4%), while nearly one in five had diabetes mellitus (19.6%). Notably, 58.9% reported decreased hearing, and 16.1% experienced tinnitus, conditions often associated with prolonged exposure to hazardous noise levels. Participants in the low ONEL group had a higher prevalence of hypertension (80%) and diabetes (30%) compared to those in the high ONEL group, possibly due to age and comorbidity factors. These health risks have been previously associated with hearing loss through vascular and metabolic pathways that affect cochlear blood flow and hair cell integrity (Wu et al., 2020).

The prevalence of abnormal audiometric outcomes was most pronounced at higher frequencies, particularly at 4000 Hz and 8000 Hz. At 4000 Hz, 63% of the high ONEL group and 70% of the low ONEL group demonstrated abnormal hearing thresholds. This increased to 50% and 90%, respectively, at 8000 Hz. The observed high-frequency threshold shifts are characteristic of early-onset noise-induced hearing loss (NIHL), often manifesting at or around 4 kHz due to damage in the basal turn of the cochlea (Basner et al., 2019; Wang & Liu, 2023). These results align with regional findings. For example, Ong et al. (2024) reported similar patterns among MMDA traffic enforcers in Metro Manila, where individuals exposed to >85 dBA had significantly higher risks of hearing loss at 4000 Hz and above. This reinforces the evidence that occupational exposure in urban traffic environments contributes substantially to sensorineural hearing deficits.

Interestingly, although the low ONEL group reported lower occupational exposure, their rate of hearing abnormality at 8000 Hz (90%) exceeded that of the high ONEL group (50%). This discrepancy may be explained by other contributing factors such as age-related hearing decline (presbycusis), recreational noise exposure, or comorbidities. Indeed, presbycusis typically affects the higher frequencies first and is exacerbated by conditions like hypertension and diabetes, which were more prevalent in the low ONEL group (Loughrey et al., 2018).

Hearing threshold outcomes for both the right and left ears revealed varying degrees of hearing impairment. In the right ear, only 37.5% of participants had normal hearing, while the rest presented with mild (39.3%),

moderate (3.6%), moderately severe (7.1%), or profound hearing loss (1.8%). Patterns were similar in the left ear, where 46.4% had normal thresholds, but 33.9% exhibited mild hearing loss and another 18% demonstrated varying degrees of moderate to severe loss. These findings are consistent with a study by Naha et al. (2020), which found a comparable distribution of hearing loss severity among Dhaka traffic officers, particularly in individuals with longer service duration.

Duration of service also appears to influence hearing outcomes. Participants with over 10 years of service made up 93% of the high ONEL group. This supports findings that cumulative noise exposure, even when intermittent, can lead to permanent threshold shifts over time (Lie et al., 2021). The strong presence of mild-to-moderate high-frequency loss among long-serving personnel indicates a progressive auditory decline that may be mitigated by early detection and protective strategies.

Lifestyle factors further compound the risk. About 25% of participants used earphones at work, and 55.4% reported exposure to recreational noise. Both factors have been implicated in early-onset hearing damage in younger populations (WHO, 2019). Moreover, 42.9% of participants were regular or occasional drinkers, and 23.2% were current smokers—habits that have been associated with increased susceptibility to auditory damage through mechanisms such as oxidative stress and cochlear microcirculation impairment (Curhan et al., 2020).

The Pure Tone Audiometry (PTA) results further underscore the audiological impact of noise exposure. The percentage of

participants with abnormal thresholds rose steadily with frequency, from 18% at 500 Hz to 57.1% at 8000 Hz. This progression confirms the characteristic audiogram “notch” of NIHL, typically observed between 3000–6000 Hz and deepening with continued exposure. PTA remains the gold standard for detecting early signs of hearing deterioration, especially in occupational health monitoring (Miller et al., 2022). The observed trend of worsening thresholds at higher frequencies supports the use of PTA as an essential tool for surveillance in noise-exposed occupations.

Collectively, these results reveal a consistent pattern of hearing deterioration attributable to occupational noise exposure, personal health conditions, and lifestyle factors. The convergence of high-frequency hearing loss in both high and low ONEL groups, coupled with significant comorbidities and lifestyle risks, calls for comprehensive audiological monitoring and policy interventions. Programs focused on regular hearing screenings, use of personal protective equipment, health education, and reduction of non-occupational noise exposure could mitigate further hearing decline among traffic enforcers.

Table 2 presents the Chi-square results, showing that most demographic, health, and lifestyle variables—including age—did not exhibit statistically significant associations with ONEL. The only statistically significant association was observed at the 8000 Hz audiometric frequency ($\chi^2 = 5.37$, $p = 0.027$) (see Table 2.). This finding suggests that occupational noise exposure may specifically impact hearing sensitivity at this high-frequency range. All other variables, including hypertension, diabetes, sex, smoking, alcohol consumption, deployment

location, and years of service, yielded p -values above 0.05, indicating no significant associations.

The findings paint a comprehensive picture of the auditory health status and occupational risks faced by traffic enforcers in Cebu City. They suggest that while certain demographic and lifestyle factors may not directly influence exposure levels, the physiological outcome—hearing loss—is still evident. This reflects the cumulative and chronic nature of NIHL and signals the urgent need for proactive measures, including the use of hearing protection devices, noise zoning, and routine screening to mitigate long-term health effects among urban enforcement personnel. The associations between the characteristics of traffic enforcers and their level of occupational noise exposure (ONEL) were analyzed using chi-square (χ^2) tests. Most of the personal, health, and occupational variables examined in this study were not significantly associated with ONEL, indicating that these characteristics were evenly distributed between high and low ONEL groups. However, one audiometric frequency—8000 Hz—showed a statistically significant association with ONEL ($p = 0.027$), suggesting that occupational exposure may specifically affect hearing thresholds at this high frequency.

Age, sex, and chronic conditions such as hypertension ($p = 0.084$) and diabetes mellitus ($p = 0.363$) showed no significant association with ONEL. This may imply that while these variables are known risk factors for hearing loss (Wu et al., 2020; Curhan et al., 2020), they do not differentiate between high and low exposure groups in this population. Similarly, lifestyle behaviors such as smoking ($p = 0.116$) and alcohol

consumption ($p = 0.468$) did not vary significantly across ONEL groups. Although these factors are established contributors to auditory degeneration (Lie et al., 2021), their influence may be independent of workplace noise exposure or masked by other variables such as age and comorbidities.

Interestingly, subjective hearing complaints—such as decreased hearing ($p = 0.939$) and tinnitus ($p = 0.186$)—were not significantly associated with ONEL. This finding aligns with the notion that individuals may underreport auditory symptoms despite measurable deficits, particularly in noise-exposed populations where gradual onset often leads to habituation (Basner et al., 2019). Similarly, earphone use at work ($p = 0.687$) and exposure to recreational noise ($p = 0.107$) were not significantly linked to ONEL. Nevertheless, these activities are still considered important non-occupational contributors to auditory fatigue and should not be disregarded in preventive health strategies (WHO, 2019).

The lack of association between hearing health outcomes and ONEL at most audiometric frequencies (500–4000 Hz) may reflect early or subclinical stages of hearing damage in this group. However, a significant association was detected at 8000 Hz ($\chi^2 = 5.37$, $p = 0.027$), supporting the well-established pattern that high-frequency thresholds are the first to be affected by prolonged noise exposure (Miller et al., 2022). The sensitivity of the 8000 Hz threshold in detecting early cochlear damage highlights its diagnostic utility in occupational audiometry and supports recommendations for including extended high-frequency testing in surveillance programs (Wang & Liu, 2023).

Additionally, no significant associations were found between ONEL and hearing thresholds of the right ear ($p = 0.436$) or left ear ($p = 0.161$) when viewed holistically. This suggests that overall ear-specific hearing loss may not vary dramatically by exposure level, possibly due to bilateral and symmetric exposure in traffic environments. However, sub-frequency differences such as that seen at 8000 Hz warrant closer examination.

Duration of service also did not show a significant association with ONEL ($p = 0.273$), which contrasts with literature indicating cumulative exposure effects over time (Ong et al., 2024). One explanation may be that traffic enforcers rotate between locations with varying noise levels or that individual differences in susceptibility play a role in hearing outcomes.

While most demographic and lifestyle factors were not significantly associated with ONEL, a critical finding emerged at 8000 Hz, where exposure level significantly affected hearing thresholds. This supports the established progression of noise-induced hearing loss, where early damage occurs at higher frequencies before progressing downward (Loughrey et al., 2018). These results reinforce the need for regular high-frequency audiometric testing and targeted hearing conservation strategies in occupational health frameworks.

An analysis of the associations between traffic enforcers' characteristics and their Pure Tone Audiometry (PTA) results revealed several statistically significant relationships, particularly with age and health-related variables is shown in Table 3 (see Table 3.). Most notably, age showed a significant association with hearing

thresholds in both the right ($\chi^2 = 31.0$, Cramer's $V = 0.372$, $p = 0.013$) and left ears ($\chi^2 = 31.4$, Cramer's $V = 0.374$, $p = 0.012$). These findings are consistent with the global understanding of presbycusis or age-related hearing loss, where gradual sensorineural deterioration begins in the high-frequency range and is often symmetrical between ears (Yamasoba et al., 2020). The moderate effect size indicated by Cramer's V further supports the clinical relevance of age as a determinant in hearing decline among traffic enforcers.

Another key finding is the significant association between general health outcomes related to hearing loss and PTA thresholds for both ears. The right ear showed a χ^2 value of 10.4 ($p = 0.015$), while the left ear had a χ^2 of 11.2 ($p = 0.011$), suggesting that individuals who report broader hearing-related health issues tend to exhibit measurable hearing deficits. These outcomes reinforce existing literature on the link between comorbid chronic conditions and auditory dysfunction (Lin et al., 2019). It also emphasizes the importance of a holistic health evaluation in occupational hearing conservation programs, where cardiovascular risk factors, diabetes, and lifestyle choices can compound the effects of environmental noise exposure (Khan et al., 2021).

In contrast, most other individual and lifestyle characteristics—such as sex, smoking status, alcohol consumption, and earphone use at work—did not show statistically significant associations with PTA results in either ear. While smoking and alcohol are frequently cited in literature as modifiable risk factors for auditory damage (Lie et al., 2021), their lack of significance in this study could be due to either small

subgroup sizes or overlapping variance with other stronger predictors like age. Similarly, the use of earphones at work and recreational noise exposure were not significantly associated with hearing thresholds ($p > 0.05$), although recreational noise exposure approached significance for the right ear ($\chi^2 = 2.78$, $p = 0.096$), suggesting a trend worth monitoring. These results highlight the challenges in isolating the impact of recreational noise in populations already exposed to occupational noise sources.

Interestingly, occupational noise exposure level (ONEL), which had been significantly associated with the 8000 Hz threshold in the earlier analysis (see Table 2), was not significantly associated with overall PTA results in this analysis (right ear $p = 0.436$; left ear $p = 0.161$). This discrepancy may suggest that ONEL has frequency-specific effects—particularly at higher frequencies not captured in the aggregated PTA data—or that its effect is moderated by other individual-level factors such as age or pre-existing comorbidities (Miller et al., 2022). The non-significant relationship between ONEL and total PTA may also indicate that extended duration of exposure, rather than the level alone, is more predictive of long-term audiometric outcomes (Wang & Liu, 2023).

Duration of service did not reach statistical significance but approached it for the left ear ($\chi^2 = 10.9$, $p = 0.091$), suggesting a potential cumulative effect of prolonged occupational exposure. This is aligned with existing evidence that longer exposure to high-decibel environments contributes to gradual, bilateral hearing degradation, particularly among workers in transportation and law enforcement (Ong et al., 2024). This trend warrants further investigation with larger

sample sizes or longitudinal follow-up to detect changes over time.

Overall, these results confirm that age and self-reported hearing health status are the most robust predictors of PTA-measured hearing loss among traffic enforcers. Other lifestyle and occupational variables showed non-significant relationships, possibly due to overlapping effects, measurement limitations, or relatively short exposure duration. These findings underscore the importance of early audiological screening, age-sensitive hearing protection protocols, and comprehensive health monitoring for traffic enforcers regularly exposed to high-noise environments.

CONCLUSION

This study set out to examine the auditory health status of traffic enforcers in Cebu City by assessing their occupational noise exposure levels (ONEL) and how these relate to various demographic, health, and lifestyle factors. The use of Pure Tone Audiometry (PTA) provided objective data on hearing thresholds across key frequencies, enabling a more accurate assessment of occupational hearing health.

The findings reveal that although a majority of traffic enforcers were classified under the high ONEL group, only the hearing threshold at 8000 Hz showed a statistically significant association with noise exposure. This suggests that high-frequency hearing loss may be an early indicator of noise-induced hearing damage. Similar findings have been reported in recent occupational health literature, which points to high-frequency thresholds—particularly at 4000 and 8000 Hz—as being the most vulnerable

to long-term noise exposure (Hong et al., 2021; Neitzel et al., 2019). However, no other frequency or audiometric outcome showed a significant association with ONEL, indicating that factors beyond occupational noise may also contribute substantially to auditory decline.

Notably, age and self-reported health outcomes related to hearing loss demonstrated significant associations with PTA results in both ears. The data indicate that as traffic enforcers age, they are more likely to present abnormal hearing thresholds, consistent with age-related hearing loss or presbycusis. This supports global evidence suggesting that occupational noise exposure and aging act as synergistic risk factors for hearing loss (Lee et al., 2020; Rabinowitz, 2018). Additionally, traffic enforcers who already reported health issues attributed to hearing loss exhibited poorer audiometric profiles, underscoring the need for preventive measures that begin with early detection and health education.

Surprisingly, lifestyle factors such as smoking, alcohol consumption, and recreational noise exposure were not statistically significant in association with hearing thresholds or ONEL. This contradicts some studies that have found strong links between lifestyle behaviors and auditory function (Zhao et al., 2019), suggesting either a limited sample size or that occupational and aging factors may overshadow these variables in this specific context.

The study also found no significant relationship between ONEL and sex, comorbid conditions like hypertension and diabetes, duration of service, or use of earphones. This implies that ONEL, while

important, may not independently predict hearing loss outcomes in the absence of other compounding factors. It also reinforces the view that occupational hearing loss is multifactorial and often context-dependent (Sliwinska-Kowalska & Davis, 2020).

Given these findings, several key implications arise. First, while occupational noise remains a concern, it should not be viewed in isolation. A more holistic approach to hearing conservation is warranted—one that considers age, comorbidities, and general health. Second, the significant association of hearing loss at 8000 Hz with ONEL suggests that high-frequency audiometry could serve as a screening tool for early detection in exposed populations. Third, regular and mandatory audiometric testing for traffic enforcers, especially those over the age of 40, should be institutionalized as part of occupational health policies. Such measures have been recommended in recent guidelines for workplace health promotion (World Health Organization, 2022).

Furthermore, educational initiatives to increase awareness of noise-induced hearing loss, particularly regarding recreational noise and the use of personal audio devices, could support a culture of prevention. Finally, it is recommended that local government units consider providing personal protective equipment such as noise-canceling earplugs and enforce periodic reassessment of sound levels in high-traffic duty locations.

In conclusion, this study provides critical insight into the hearing health of a high-risk occupational group in an urban Philippine setting. While occupational noise exposure is a contributing factor to auditory decline—

especially at higher frequencies—its effects are significantly influenced by age and existing hearing-related health outcomes. These results highlight the need for a multidimensional intervention strategy that combines audiometric surveillance, lifestyle modification, protective policy, and public health education. Future studies should aim to increase sample size, utilize longitudinal designs, and investigate the cumulative impact of noise exposure over time to further substantiate these findings and inform policy on occupational hearing health.

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Table 1.

Characteristics of study participants, classified by occupational noise exposure level (n=56)

Characteristic	High ONEL (n=46)	Low ONEL (n=10)	Total (n=56)
Age (years), mean (SD)	44.0 (8.21)	47.9 (12.0)	44.8 (9.0)
Sex			
Male	45 (97.8)	10 (100.0)	55 (98.2)
Female	1 (2.2)	-	1 (1.8)
Health History			
Hypertensive	24 (52.2)	8 (80.0)	31 (55.4)
With Diabetes Miletus	8 (17.4)	3 (30.0)	11 (19.6)
With decreased hearing	27 (58.7)	6 (60.0)	33 (58.9)
With tinnitus	6 (13.0)	3 (30.0)	9 (16.1)
User of earphones at work	11 (23.9)	3 (30.0)	14 (25.0)
Exposed to recreational noise	24 (52.2)	8 (80.0)	31 (55.4)
Health Outcomes with hearing loss	5 (10.9)	2 (20.0)	7 (12.5)
Location			
A	17 (37.0)	5 (50.0)	22 (39.3)
B	10 (21.7)	3 (30.0)	13 (23.2)
C	19 (41.3)	2 (20.0)	21 (37.5)
Duration of Service (yrs.)			
5-9	3 (6.5)	1 (10.0)	4 (7.1)
10-14	22 (47.8)	2 (20.0)	24 (43.0)
<15	21 (45.7)	7 (70.0)	28 (50.0)
Lifestyle			
Smoking Status			
Never smoked	27 (58.7)	5 (50.0)	32 (57.1)
Past smoker	7 (15.2)	4 (40.0)	11 (19.6)
Current smoker	12 (26.1)	1 (10.0)	13 (23.2)
Alcohol Status			
Nondrinker	10 (21.7)	4 (40.0)	14 (25.0)
Occasional drinker	22 (47.8)	4 (40.0)	26 (46.4)
Regular drinker	14 (30.4)	2 (20.0)	16 (28.6)
Audiometric Outcomes			
Air Conduction Pure Tone Audiometry (PTA)			
Normal at 500 Hz	39 (84.8)	7 (70.0)	46 (82.1)
Abnormal at 500 Hz	7 (15.2)	3 (30.0)	10 (18.0)

Normal at 1000 Hz	35 (76.1)	5 (50.0)	40 (71.4)
Abnormal at 1000 Hz	11 (23.9)	5 (50.0)	16 (28.6)
Normal at 2000 Hz	38 (82.6)	6 (60.0)	44 (78.6)
Abnormal at 2000 Hz	8 (17.4)	4 (40.0)	12 (21.4)
Normal at 4000 Hz	17 (37.0)	3 (30.0)	20 (35.7)
Abnormal at 4000 Hz	29 (63.0)	7 (70.0)	36 (64.3)
Normal at 8000 Hz	23 (50.0)	1 (10.0)	24 (42.9)
Abnormal at 8000 Hz	23 (50.0)	9 (90.0)	32 (57.1)
Right Ear			
Normal Hearing Threshold Level	19 (41.3)	2 (20.0)	21 (37.5)
Normal Hearing Threshold with DIP at 8000 Hz	1 (2.2)	-	1 (1.8)
Mild Hearing Loss	18 (39.1)	4 (40.0)	22 (39.3)
Mild Hearing Loss Falling Towards the Higher Frequencies	1 (2.2)	1 (10.0)	2 (3.6)
Moderate Hearing Loss	2 (4.3)	-	2 (3.6)
Moderate Hearing Loss Falling Towards the Higher Frequencies	2 (4.3)	2 (20.0)	4 (7.1)
Moderately Severe Hearing Loss Falling Towards the Higher Frequencies	1 (2.2)	1 (10.0)	2 (3.6)
Moderately Severe Hearing Loss	1 (2.2)	-	1 (1.8)
Profound Hearing Loss	1 (2.2)	-	1 (1.8)
Left			
Normal Hearing Threshold Level	24 (52.2)	2 (20.0)	26 (46.4)
Normal Hearing Threshold with DIP at 4000 Hz	1 (2.2)	-	1 (1.8)
Mild Hearing Loss	14 (30.4)	5 (50.0)	19 (33.9)
Mild Hearing Loss Falling Towards the Higher Frequencies	2 (4.3)	1 (10.0)	3 (5.4)
Moderate Hearing Loss	3 (6.5)	-	3 (5.4)
Moderate Hearing Loss Abruptly Falling Towards the Higher Frequencies	-	2 (20.0)	2 (3.6)
Moderately Severe Hearing Loss Falling Towards the Higher Frequencies	1 (2.2)	-	1 (1.8)
Severe Hearing Loss	1 (2.2)	-	1 (1.8)

Table 2.

Association Between Characteristics of Traffic Enforcers and their Occupational Noise Exposure Level (ONEL)

Characteristic	X ²	p-value
Age	5.48	0.241 ^{ns}
Sex	0.221	0.638 ^{ns}
Hypertensive	2.99	0.084 ^{ns}
With Diabetes Miletus	0.827	0.363 ^{ns}
Smoking Status	3.59	0.116 ^{ns}
Alcohol Status	1.52	0.468 ^{ns}
With decreased hearing	0.006	0.939 ^{ns}
With tinnitus	1.75	0.186 ^{ns}
User of earphones at work	0.162	0.687 ^{ns}
Exposed to recreational noise	2.60	0.107 ^{ns}
Health Outcomes with hearing loss	0.626	0.429 ^{ns}
Location	1.59	0.451 ^{ns}
Duration of Service	2.60	0.273 ^{ns}
Air Conduction PTA		
500 Hz	1.22	0.269 ^{ns}
1000 Hz	2.74	0.098 ^{ns}
2000 Hz	2.49	0.114 ^{ns}
4000 Hz	0.173	0.677 ^{ns}
8000 Hz	5.37 (0.320)	0.027 *
Right Ear	2.72	0.436 ^{ns}
Left Ear	5.15	0.161 ^{ns}

ns = not significant at 5% level of significance (p>0.05)

Table 3.

Association Between Characteristics of Traffic Enforcers and their Pure Tone Audiometry (PTA)

Characteristic	RIGHT EAR		LEFT EAR	
	X ² (Cramer's V)	p-value	X ² (Cramer's V)	p-value
Age	31.0 (0.372)	0.013*	31.4 (0.374)	0.012*
Sex	1.36	0.852 ^{ns}	1.09	0.895 ^{ns}
Hypertensive	4.93	0.295 ^{ns}	4.31	0.365 ^{ns}
With Diabetes Miletus	0.891	0.828 ^{ns}	3.34	0.342 ^{ns}
Smoking Status	1.26	0.974 ^{ns}	3.56	0.737 ^{ns}
Alcohol Status	6.72	0.348 ^{ns}	5.70	0.457 ^{ns}
With decreased hearing	6.75	0.080 ^{ns}	1.63	0.653 ^{ns}
With tinnitus	0.634	0.889 ^{ns}	0.306	0.959 ^{ns}
User of earphones at work	2.70	0.440 ^{ns}	2.70	0.440 ^{ns}
Exposed to recreational noise	2.78	0.096 ^{ns}	2.34	0.504 ^{ns}
Health Outcomes with hearing loss	10.4	0.015 *	11.2	0.011 *
Occupational Noise Exposure Level	2.72	0.436 ^{ns}	5.51	0.161 ^{ns}
Location	8.97	0.440 ^{ns}	9.72	0.373 ^{ns}
Duration of Service	9.51	0.147 ^{ns}	10.9	0.091 ^{ns}

ns = not significant at 5% level of significance (p>0.05) * significant at 5% level of significance (p<0.05)