JUKEKE Jurnal Kesehatan dan Kedokteran
OPEN ACCESS
JUKEKE Vol 5 No. 3 October 2026 | ISSN: 2829-0437 (Print), ISSN: 2829-050X (online), Page 936-952

Ear Health Status and Auditory Function Profile of First-Semester Medical Students at Universitas 'Aisyiyah Yogyakarta in the 2025/2026 Academic Year

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Article History
Received : August 27, 2026
Revised : November 10, 2026
Accepted : November 12, 2026
Published : November 13, 2026

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Cite This Article *[APA Style]:*
Soeratman, U. N. F., Fa'izah, C. N., & Anggara, M. . J. H. (2026). Ear Health Status and Auditory Function Profile of First-Semester Medical Students at Universitas 'Aisyiyah Yogyakarta in the 2025/2026 Academic Year. *Jurnal Kesehatan Dan Kedokteran*, *5*(3), 936–952.

DOI:
https://doi.org/10.56127/jukeke.v5i3.3093

Abstract: Ear health is essential for effective communication and academic participation, yet ear-related complaints and potential hearing abnormalities may remain undetected among university students. **Objective:** This study aimed to describe ear health status and bedside auditory function among first-semester medical students at Universitas 'Aisyiyah Yogyakarta during the 2025/2026 academic year. **Methodology:** A quantitative descriptive cross-sectional study was conducted involving 41 medical students. Primary data were collected through questionnaires, physical ear examinations, otoscopy, and Rinne, Weber, and Schwabach tuning-fork tests. Data were analyzed using descriptive statistics, including frequencies and percentages. **Findings:** The most frequently reported complaints were itchy or watery ears (29.3%), tinnitus (19.5%), and ear pain (12.2%). Cerumen was detected in 29.3% of right ears and 22.0% of left ears, while all respondents had normal external auditory canal findings. Positive Rinne results, absence of Weber lateralization, and Schwabach results equivalent to the examiner were each observed in 85.4% of respondents. **Implications:** These findings support ear health education, symptom awareness, and appropriate audiological referral for students with concerning clinical findings. **Originality:** This study provides institution-specific baseline data by integrating self-reported symptoms, otoscopic examinations, and bedside hearing assessments within a single descriptive framework for first-semester medical students.

Keywords: ear health; medical students; tuning-fork examination.

INTRODUCTION

Hearing is an essential sensory function that plays an important role in communication, learning, social interaction, and participation in daily activities. Hearing health is particularly relevant among university students because adequate auditory function is required to receive and process information effectively in academic environments. The

World Health Organization (WHO) emphasizes that hearing loss can affect communication, education, employment, and social participation, while many causes of hearing loss are preventable. In addition, more than one billion adolescents and young adults are estimated to be at risk of avoidable hearing loss due to unsafe listening practices, particularly listening to loud sounds or music for prolonged periods (World Health, 2021).

Hearing problems may also occur in young adults and university students. A recent meta-analysis involving college students reported an overall prevalence of hearing loss of approximately 19%, demonstrating that hearing impairment is not exclusively a problem of older populations (Kornisch et al., 2024). In addition to hearing impairment, common ear conditions such as cerumen accumulation may interfere with examination of the ear canal and tympanic membrane and may be associated with symptoms such as hearing difficulty, ear discomfort, or tinnitus (Alshamrani et al., 2022). Cerumen impaction is diagnosed through direct visualization using otoscopy and remains a common clinical problem in primary care (Horton et al., 2020)

The use of personal listening devices, including earphones and headphones, is another relevant concern among adolescents and young adults. A systematic review and meta-analysis by (Dillard et al., 2022) demonstrated a high prevalence of unsafe listening practices among adolescents and young adults, highlighting prolonged and high-volume exposure to personal listening devices and loud recreational environments as important preventable risks for hearing impairment. Therefore, assessment of ear health among university students is important not only for identifying existing ear abnormalities but also for supporting early recognition and prevention of potentially modifiable hearing-related problems.

Previous Previous research regarding ear and hearing health among young people can broadly be categorized into several areas. First, epidemiological studies have evaluated the prevalence of hearing impairment among university students. (Kornisch et al., 2024), through a meta-analysis of studies involving college students aged 17–35 years, reported an overall hearing loss prevalence of approximately 19%, supporting the importance of hearing screening and preventive strategies in the university population.

Second, studies on unsafe listening practices have highlighted the potential risk associated with personal listening devices and recreational noise exposure. (Dillard et al., 2022) reported that unsafe listening practices are common among adolescents and young

adults, indicating that exposure to excessive sound intensity and prolonged listening duration represents an important preventable public health concern. The WHO also identifies unsafe listening as a major preventable contributor to hearing loss among adolescents and young adults (World Health, 2021).

Third, clinical studies of external ear conditions have examined conditions such as cerumen accumulation. (Horton et al., 2020) emphasized that cerumen impaction is a common otologic condition and that direct visualization through otoscopy is important for diagnosis and assessment of the external auditory canal and tympanic membrane.

Fourth, clinical screening approaches have incorporated simple bedside hearing assessments, including the Rinne and Weber tuning-fork tests. The British Society of Audiology provides a standardized recommended procedure for the performance and interpretation of Rinne and Weber tuning-fork tests, supporting their use as clinical bedside assessments of hearing function.

Despite these contributions, studies specifically describing the overall ear health profile of first-semester medical students remain limited, particularly studies that combine self-reported ear-related complaints with physical ear examination, otoscopy, and tuning-fork testing within a single descriptive assessment. Most available studies focus on specific outcomes such as hearing loss, unsafe listening behavior, tinnitus, or cerumen rather than providing an integrated baseline profile of ear health in medical students. Therefore, this study addresses this gap by providing a descriptive baseline assessment of ear health among first-semester medical students at Universitas ‘Aisyiyah Yogyakarta during the 2025/2026 academic year.

This study aims to describe the ear health status of first-semester students of the Faculty of Medicine, Universitas ‘Aisyiyah Yogyakarta, during the 2025/2026 academic year. Specifically, the study aims to:

1. **Describe the frequency and types of ear-related complaints**, including ear pain, tinnitus, hearing difficulties, and itchy or wet ears, based on questionnaire responses.
2. **Describe the findings of physical ear and otoscopic examinations**, including the presence or absence of cerumen and the condition of the external auditory canal.
3. **Describe hearing function based on Rinne, Weber, and Schwabach tuning-fork tests** using a 512-Hz tuning fork.

4. **Describe relevant respondent characteristics**, including age, sex, and earphone-use habits, in relation to the overall profile of ear health among the study participants.

The novelty of this study lies in providing a baseline descriptive profile of ear health specifically among first-semester medical students at Universitas 'Aisyiyah Yogyakarta. Rather than focusing on a single ear condition, the study integrates self-reported ear-related complaints, physical ear examination, otoscopic findings, and bedside tuning-fork tests within a single assessment framework. The findings are expected to provide preliminary empirical data that can support further research on ear health risk factors among university students and contribute to the development of promotive and preventive ear-health education programs. The results may also serve as baseline information for future studies involving larger populations, more comprehensive audiological assessments, and evaluation of interventions aimed at improving hearing-health awareness and safe listening practices.

RESEARCH METHOD

The unit of analysis in this study is the ear health status of active first-semester medical students of Universitas 'Aisyiyah Yogyakarta in the 2025/2026 academic year, assessed through questionnaire responses, physical ear examination, otoscopic examination, and tuning-fork tests.

This study uses a quantitative descriptive cross-sectional design. The study is conducted at a single point in time to describe the ear health status of active first-semester medical students. This design is considered suitable for identifying the distribution and frequency of normal and abnormal ear conditions as well as reported ear-related complaints among the study population.

The data are obtained from primary data collected directly from the respondents. The data include demographic characteristics such as age and sex, ear-related complaints obtained through questionnaires, and findings from physical ear examination, otoscopy, and tuning-fork tests. The study population consists of all active first-semester medical students of Universitas 'Aisyiyah Yogyakarta in the 2025/2026 academic year who meet the inclusion criteria and provide written informed consent.

Data collection is conducted on a single designated day. Before examination, participants are provided with an explanation of the study procedures and asked to provide written informed consent. Data collection is performed systematically, beginning with identification of age and sex, followed by external physical examination of the ears, otoscopic examination, and tuning-fork tests. The examination findings and questionnaire responses are recorded on prepared data collection sheets. Participants who are absent, unwilling to participate, or currently ill are excluded according to the predetermined exclusion criteria. The collected data are subsequently processed and analyzed descriptively using frequency, percentage, mean, and standard deviation to describe the participants' ear health status and the frequency of ear-related complaints.

The collected data are processed and analyzed using descriptive statistical methods. The analysis includes frequency and percentage for categorical variables, while mean and standard deviation are used for numerical variables. The descriptive analysis is performed to determine the distribution of respondents' characteristics, the frequency of ear-related complaints, and the proportion of normal and abnormal ear examination findings. The results are presented in tables and descriptive summaries to provide an overview of the ear health status of active first-semester medical students.

The stages of the research consist of research preparation, determination of the study population and eligibility criteria, obtaining informed consent, questionnaire administration, physical ear examination, otoscopic examination, tuning-fork testing, data recording, data processing and analysis, interpretation of findings, and preparation of the research results and conclusions.

RESULT

This study was conducted at Universitas 'Aisyiyah Yogyakarta using a cross-sectional study design, in which data were collected at a single point in time to assess the ear health status of active first-semester students during the 2025/2026 academic year. A total of 41 respondents were included in the study after meeting the predetermined inclusion and exclusion criteria. The data collected included respondent characteristics, ear-related complaints, history of *earphone* use, and ear examination findings, including otoscopic examination and tuning-fork tests.

The demographic characteristics analyzed in this study included sex and age. The distribution of respondent characteristics is presented in Tables 2 and 3, including the frequency and percentage of sex and age categories, as well as descriptive statistics for age.

Table 2. Respondent Characteristics

Characteristics	Frequency (n=41)	Percentage (%)
Sex		
Male	6	14,6
Female	35	85,4
Total	41	100,0
Age (years)		
18	7	17,1
19	28	68,3
20	4	9,8
21	2	4,9
Total	41	100,0

Table 3. Respondent Age Characteristics

Characteristic	Frequency (n)	Minimum	Maximum	Mean	Standard Deviation
Age	42	18	21	19,02	0,689

A total of 41 respondents participated in the study. Respondent characteristics were described based on sex and age to provide an overview of the demographic distribution of the study population.

Based on Table 2, the majority of respondents were female, comprising 35 participants (85.4%), while 6 respondents (14.6%) were male. According to Table 3, the mean age of the respondents was 19.02 ± 0.69 years, with an age range of 18–21 years. Based on the age group distribution, most respondents were 19 years old (68.3%), followed by those aged 18 years (17.1%), 20 years (9.8%), and 21 years (4.9%).

The demographic characteristics indicate that the study population was predominantly female and within a relatively narrow age range of 18–21 years. The predominance of respondents aged 19 years reflects the typical age distribution of first-semester medical students. This relatively homogeneous age distribution provides a consistent demographic context for describing the ear health status of the study population.

Ear-related complaints were assessed based on symptoms experienced by respondents during the previous six months, including ear pain, tinnitus, hearing impairment, and itchy

or watery ears. The study also assessed the respondents' habit of using *earphones* for more than one hour per day.

Table 4. Ear-Related Complaints

Ear-related complaint	Frequency	Percentage (%)
Ear pain during the previous 6 months		
No	36	87,8
Yes	5	12,2
Total	41	100,0
Tinnitus		
No	33	80,5
Yes	8	19,5
Total	41	100,0
Hearing impairment		
No	40	97,6
Yes	1	2,4
Total	41	100,0
Itchy or watery ears		
No	29	70,6
Yes	12	29,3
Total	41	100,0

Based on Table 4, most respondents did not report ear-related complaints during the previous six months. Among the assessed complaints, itchy or watery ears were the most frequently reported symptom, affecting 12 respondents (29.3%), followed by tinnitus in 8 respondents (19.5%), ear pain in 5 respondents (12.2%), and hearing impairment in 1 respondent (2.4%).

Several patterns were observed. First, most respondents did not report ear pain, tinnitus, or hearing impairment. Second, itchy or watery ears were the most common complaint, occurring in nearly one-third of respondents. Third, tinnitus was reported by approximately one-fifth of respondents. Fourth, hearing impairment was uncommon, being reported by only one respondent.

The findings indicate that the overall prevalence of reported ear-related complaints in this study population was relatively low. However, itchy or watery ears represented the most common complaint and may indicate the presence of minor external ear symptoms that warrant attention. Tinnitus was also reported by a notable proportion of respondents. These findings highlight the importance of routine ear-health education and awareness of early ear-related symptoms among young adults.

Table 5. Respondents *Earphone* Use Habits

***Earphone* use >1 hour/day**	**Frequency**	**Percentage (%)**
No	33	80,5
Yes	8	19,5
Total	41	100,0

Based on Table 5, the majority of respondents did not use *earphones* for more than one hour per day, with 33 respondents (80.5%) reporting no such use. In contrast, 8 respondents (19.5%) reported using *earphones* for more than one hour per day.

The dominant pattern was that most respondents reported limited daily *earphone* use. Only approximately one-fifth of respondents exceeded one hour of daily *earphone* use, while four-fifths reported using *earphones* for one hour or less per day.

The findings suggest that prolonged *earphone* use was not common among the study participants. Nevertheless, because prolonged exposure to personal listening devices may be relevant to hearing health, preventive education regarding safe listening practices remains important. In this descriptive study, however, the relationship between *earphone* use and ear-related complaints was not statistically assessed and therefore cannot be interpreted as a causal association.

Ear examination was performed using otoscopy to assess the presence of cerumen and the condition of the *canalis auricula externa* (CAE) in both ears of the respondents. The results of the physical ear examination are presented in Table 6.

Table 6. Physical Ear Examination Findings

Examination finding	**Frequency**	**Percentage (%)**
Cerumen in right CAE (*Dextra*)		
Absent	29	70,7
Present	12	29,3
Total	41	100,0
Right CAE (*Dextra*)		
Normal	41	100,0
Abnormal	0	0,0
Total	41	100.0
Cerumen in left CAE (*Sinistra*)		
Absent	32	78,0
Present	9	22,0
Total	41	100,0
Left CAE (*Sinistra*)		

Examination finding	Frequency	Percentage (%)
Normal	41	100,0
Abnormal	0	0,00
Total	41	100,0

The otoscopic examination showed that most respondents did not have visible ear cerumen. Cerumen was identified in 12 respondents (29.3%) in the right ear and 9 respondents (22.0%) in the left ear. All respondents demonstrated normal CAE findings in both ears.

Three dominant findings were observed. First, the majority of respondents had no visible cerumen in either ear. Second, cerumen was slightly more frequently identified in the right ear than in the left ear. Third, all respondents had normal CAE findings in both ears, with no abnormal findings recorded during the examination.

The otoscopic findings indicate that the external ear canals of the respondents were generally in normal condition. Although cerumen was observed in a proportion of respondents, the presence of cerumen did not correspond to an abnormal CAE finding in the recorded examination. Overall, the findings suggest a predominantly normal external ear condition among the study population.

Auditory function was evaluated using standardized 512 Hz tuning fork test procedures, comprising the Rinne, Weber, and Schwabach tests to assess clinical hearing patterns across the 41 respondents.

Table 7. Tuning-Fork Examination Findings

Examination Parameter	Frequency	Percentage (%)
Rinne Test		
Positive	35	85,4
Negative	6	14,6
Total	41	100,0
Weber Test		
No lateralization	35	85,4
lateralization	6	14,6
Total	41	100,0
Schwabach Test		
Same as examiner	35	85,4
Prolonged	6	14,6
Shortened	0	0,0
Total	41	100,0

Based on Table 7, the Rinne test showed positive results in 35 respondents (85.4%), while negative results were observed in 6 respondents (14.6%). The Weber test showed no lateralization in 35 respondents (85.4%), whereas lateralization was present in 6 respondents (14.6%). In the Schwabach test, 35 respondents (85.4%) had results equivalent to the examiner, 6 respondents (14.6%) had prolonged results, and none had shortened results.

Three dominant patterns were observed across the tuning-fork examinations. First, the majority of respondents demonstrated positive Rinne results. Second, most respondents showed no lateralization on the Weber test. Third, the majority of respondents had Schwabach results equivalent to the examiner, while prolonged Schwabach findings were observed in a smaller proportion of respondents. No shortened Schwabach results were identified.

The predominance of positive Rinne results, absence of Weber lateralization, and Schwabach results equivalent to the examiner indicate that most respondents demonstrated findings consistent with generally preserved hearing function based on bedside tuning-fork assessment. The small proportion of respondents with negative Rinne results, Weber lateralization, or prolonged Schwabach findings may indicate the need for further evaluation when clinically indicated. However, these findings should be interpreted cautiously because tuning-fork tests are screening examinations and do not replace formal audiometric assessment.

DISCUSSION

The present study provides a descriptive overview of ear health status and auditory function among first-semester medical students at Universitas 'Aisyiyah Yogyakarta during the 2025/2026 academic year. The findings showed that most of the 41 respondents reported no significant ear-related complaints and demonstrated normal external auditory canal findings. However, several ear-related symptoms were identified, including itchy or watery ears (29.3%), tinnitus (19.5%), ear pain (12.2%), and self-reported hearing impairment (2.4%). Otoscopic examination identified cerumen in the right ear of 29.3% of respondents and the left ear of 22.0%, while all respondents demonstrated normal external auditory canal findings. Furthermore, tuning-fork examinations showed positive Rinne results, absence of Weber lateralization, and Schwabach results equivalent to the examiner

in 85.4% of respondents for each respective test. Nevertheless, 14.6% demonstrated negative Rinne results, Weber lateralization, or prolonged Schwabach findings. These findings indicate that although most participants exhibited reassuring clinical examination results, a proportion presented with symptoms or screening abnormalities that may warrant further evaluation.

Several factors may contribute to the observed distribution of ear-related complaints and examination findings. Itching or watery sensations in the ears may be associated with external auditory canal irritation, moisture exposure, dermatological conditions, or other localized factors, although these potential causes were not specifically investigated in the present study. Cerumen was also detected in a proportion of participants; however, its presence does not necessarily indicate pathological impaction or hearing impairment. According to (Haruna et al., 2023; Heiland et al., 2024; Horton et al., 2020) cerumen accumulation is a common clinical finding, and its significance depends on the degree of obstruction, associated symptoms, and otoscopic findings. Similarly, tinnitus may occur in young adults exposed to recreational noise or prolonged personal listening device use, although its etiology is multifactorial (Kleinjung et al., 2024). In the present study, 19.5% of respondents reported using earphones for more than one hour daily. Nevertheless, listening duration alone does not adequately characterize hazardous sound exposure because listening volume, frequency, and cumulative exposure are also relevant. Moreover, the study did not perform statistical association testing between earphone use, ear-related complaints, cerumen, and tuning-fork findings. Therefore, the observed clinical patterns should be interpreted descriptively rather than as evidence of causal relationships.

The findings can be contextualized through previous investigations of hearing health among university students and young adults. (Kornisch et al., 2024) reported an overall hearing loss prevalence of approximately 19% in a meta-analysis involving college students, emphasizing the importance of hearing health assessment in this population. In contrast, only 2.4% of respondents in the present study reported subjective hearing impairment. This difference should be interpreted cautiously because self-reported hearing difficulties and objectively determined hearing loss are distinct outcomes, and the present study did not include formal audiometric confirmation. Furthermore, (Dillard et al., 2022) identified unsafe listening practices as an important public health concern among adolescents and young adults, particularly in relation to personal listening devices and loud

recreational environments. The present study contributes additional descriptive information regarding earphone-use duration, although it did not measure actual sound exposure or establish whether participants engaged in unsafe listening practices. Regarding external ear conditions, (Horton et al., 2020; Pohan et al., 2023) highlighted the clinical importance of otoscopic examination in assessing cerumen accumulation and external auditory canal abnormalities. Unlike studies focusing primarily on hearing loss, noise exposure, or individual otologic conditions, the present research integrates self-reported symptoms, otoscopic findings, and bedside tuning-fork assessments within a single descriptive framework. Its contribution therefore lies in providing preliminary institutional baseline data rather than establishing new diagnostic relationships or causal mechanisms.

The findings have implications for understanding hearing health among medical students during the early stages of university education. Although the majority of respondents demonstrated reassuring examination findings, the presence of tinnitus, external ear symptoms, and abnormal tuning-fork results suggests that ear health concerns may exist even in a relatively young student population. The detection of abnormalities through bedside examination also illustrates the potential value of incorporating basic ear and hearing assessments into preventive health activities. Nevertheless, the interpretation of tuning-fork results requires particular caution. Positive Rinne results and the absence of Weber lateralization do not independently establish normal hearing thresholds, while abnormal findings cannot confirm the type or severity of hearing impairment without further diagnostic assessment. Consequently, the results should not be interpreted as definitive evidence of normal or impaired auditory function. Instead, they demonstrate the usefulness of a combined symptom-based and clinical screening approach for identifying participants who may benefit from additional evaluation. This interpretation is consistent with the broader preventive hearing healthcare perspective emphasized by the (World Health, 2019, 2021). From a practical perspective, the findings highlight both the potential benefits and limitations of basic ear health screening in university populations. The predominance of normal external auditory canal findings and reassuring tuning-fork results provides an initial description of the participants' clinical ear health status. Meanwhile, the identification of ear-related complaints and potentially abnormal screening findings supports the need for continued awareness and appropriate referral when clinically indicated. However, several methodological limitations must be considered. The relatively

small sample size of 41 respondents, the predominance of female participants, and the single-institution setting limit the generalizability of the findings. The cross-sectional design also prevents assessment of temporal changes or causal relationships. In addition, self-reported complaints and earphone-use habits may be affected by recall and reporting bias. The assessment of earphone use was restricted to duration and did not include listening intensity or cumulative exposure. Finally, otoscopic examination and tuning-fork tests were not supplemented by pure-tone audiometry or tympanometry, limiting the ability to identify or classify hearing disorders accurately. These limitations indicate that the findings are best regarded as preliminary descriptive evidence requiring confirmation through more comprehensive investigations.

Based on these findings, several practical actions may be considered to strengthen ear and hearing health promotion among university students. Educational programs could emphasize safe listening practices, recognition of early hearing-related symptoms, appropriate ear hygiene, and the importance of seeking medical evaluation for persistent tinnitus, ear pain, ear discharge, or hearing difficulties. The World Health Organization recommends preventive strategies to reduce avoidable hearing loss associated with unsafe listening exposure (World Health, 2019, 2021). Within medical education institutions, periodic ear health awareness activities and access to basic clinical screening may therefore be beneficial, provided that abnormal findings are followed by appropriate diagnostic evaluation. Students with persistent symptoms or concerning tuning-fork results should be considered for further assessment, including pure-tone audiometry and other examinations when clinically indicated. Future studies should involve larger and more representative samples, standardized assessment of listening behaviors, and objective audiological examinations (Langguth et al., 2024; Škerková et al., 2026; Sridharan & Sivaramakrishnan, 2021; Tolan et al., 2024). Analytical or longitudinal designs would also be valuable for investigating potential relationships between listening habits, otologic conditions, and hearing outcomes. Overall, this study provides preliminary baseline information that may support the development of context-specific preventive education and hearing health initiatives among medical students.

CONCLUSION

This study found that the majority of first-semester medical students at Universitas 'Aisyiyah Yogyakarta during the 2025/2026 academic year demonstrated generally normal external ear examination findings and predominantly reassuring bedside hearing screening results. Although most respondents reported no ear-related complaints, itchy or watery ears (29.3%), tinnitus (19.5%), and ear pain (12.2%) were identified among some participants. Otoscopic examination revealed cerumen in the right ear of 29.3% of respondents and the left ear of 22.0%, while all respondents had normal external auditory canal findings. Tuning-fork examinations showed positive Rinne results, absence of Weber lateralization, and Schwabach results equivalent to the examiner in 85.4% of respondents for each respective test. These findings indicate that although most participants exhibited reassuring clinical findings, a proportion experienced ear-related symptoms or abnormal screening results that may require further evaluation.

The scientific contribution of this study lies in providing preliminary baseline data on ear health and bedside auditory function among first-semester medical students through an integrated assessment of self-reported symptoms, otoscopic findings, and tuning-fork examinations. This descriptive approach provides an initial overview of ear health conditions in a specific university population and offers a foundation for further epidemiological investigations. The findings may also inform the development of preventive ear health education, particularly regarding safe listening practices, early recognition of ear-related symptoms, and appropriate referral for further audiological assessment when clinically indicated.

This study has several limitations, including its relatively small sample size, single-institution setting, and cross-sectional design, which restrict the generalizability of the findings and prevent causal interpretation. Self-reported complaints and earphone-use habits may also be subject to recall bias, while the absence of formal audiometric testing limits the ability to confirm or classify hearing impairment. Furthermore, the study did not examine statistical associations between earphone use, cerumen, ear-related complaints, and tuning-fork findings. Future research should involve larger and more representative samples, objective audiological assessments, and standardized measurements of personal listening device exposure. Longitudinal or analytical study designs are also recommended

to investigate potential risk factors and support the development of evidence-based hearing health interventions among university students.

DECLARATIONS

Artificial Intelligence (AI) Use Statement

The authors acknowledge the use of ChatGPT (OpenAI) to assist with academic language editing, manuscript organization, and the refinement of selected sections during manuscript preparation. All AI-assisted content was critically reviewed and verified by the authors, who retain full responsibility for the accuracy, scientific validity, originality, ethical compliance, and final content of the manuscript.

Author Contributions Statement

Uttie Nooring Fivapriliani Soeratman: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Writing – original draft.

Chintya Nur Fa'izah **:** Conceptualization, Methodology, Validation, Supervision, Writing – review & editing.

Muhammad Jamil Hamdan Anggara **:** Validation, Visualization, Supervision, Writing – review & editing.

All authors have read and approved the final version of the manuscript and agree to be accountable for their respective contributions and the integrity of the published work.

Funding Statement

This research received no external funding or specific grants from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of Interest Statement

The authors declare that they have no financial or non-financial conflicts of interest that could have influenced the design, conduct, analysis, interpretation, or reporting of this study.

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