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ORIGINAL RESEARCH

'Cultural Insights into Adults' Hearing Awareness and Personal Listening Device Habits: A Survey Study

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Objective: The aim of this study was to investigate adults' habits regarding personal listening devices (PLDs), associated factors such as tinnitus and hearing threshold shift, and their knowledge of safety measures, including the use of hearing protectors in noisy environments.

Design: A cross-sectional survey was designed and distributed online.

Study Sample: Participants between the ages of 18 and 40 years were invited to complete the survey. The online survey was filled out by 274 individuals with an average age of 24.2 years (SD= 5.1 years). Based on age, the participants were grouped into young adults (18–23 years old, 151 participants) and adults (24–40 years old, 123 participants). The estimation of noise exposure was calculated based on self-reported responses of PLD use. Two categories emerged from this calculation: the participants with exposure lower than 80 dB were in the low exposure category (N: 196, 62.9 dB), while the participants with exposure higher than 80 dB were in the high exposure category (N: 78, 89.9 dB).

Results: Based on the age categories, most of the questionnaire answers were similar between the young adults and the adults, revealing similar habits in using their PLDs. However, the investigation based on exposure revealed differences, as the participants with high exposure levels were more likely to have hobbies that involved noise, and they were less likely to obtain hearing evaluations. Among the participants, 30% used their devices at the maximum volume level and on a daily basis. 33.5% reported experiencing worsening in hearing, 2.4% reported persistent tinnitus, 94.1% knew that hearing protectors were available but only 20.7% reported using hearing protectors.

Conclusion: The study concludes that adults are at risk of hearing loss due to unsafe listening habits. A discrepancy between knowledge and practice is apparent and needs to be addressed in young adults by increasing awareness of hearing loss, hearing protection and annual hearing evaluation.

Keywords: recreation, noise exposure, tinnitus, listening habits, hearing protectors

Introduction

The World Health Organization (WHO) reported that over 1.1 billion people aged 12–35 years are at risk of hearing loss due to noise exposure in recreational settings.[1] According to the Centers for Disease Control and Prevention's (CDC) National Center for Environmental Health,[2] five in ten young people listen to music or other audio too loudly. Four in ten young people are subject to dangerously loud sounds, such as concerts and sports games.

Noise induced hearing loss (NIHL) can occur from exposure to noise at work setting and is defined as occupational noise exposure, while recreational noise exposure can be defined as voluntary exposure to noise during leisure time.[3] Recreational noise exposure can occur from attending raves, concerts, hobbies like hunting or listening to music with or without the use of personal listening devices (PLDs).

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The impact of recreational noise exposure on hearing has been well documented. It is proposed to be associated with a reduction in hearing thresholds,[4–6] tinnitus[7,8] and the presence of an audiometric notch,[9,10] several definitions have been proposed for the audiometric notch[9,11,12] with the most recent definition of

> A high-frequency notch in the air-conduction audiogram that is sufficiently large to be indicative of the probable presence of NIHL is where the hearing threshold level (HTL) at 3 and/or 4 and/or 6 kHz, after any due correction for earphone type, is at least 10 dB greater than at 1 or 2 kHz and at 6 or 8 kHz. If an average of two or more HTL measurements can be used, the 10 dB may be slightly reduced.[12]

Other health issues are also associated with noise exposure, such as annoyance, sleep disturbance and daytime sleepiness.[13] Such incidences are on the rise due to unsafe listening habits and exposure to loud sounds during leisure activities.

Dillard et al's[14] recent literature review and meta-analysis estimated the prevalence of unsafe listening practices was 23.81% among adolescents and young adults, this estimation was based on systematic review and meta-analysis of 33 publications. Vogel et al[15] reported that adolescents and young adults listen to music for over three hours per day, and most of their listening time is spent in relatively private environments. The use of PLDs is also common during physical activities, as people find loud music both enjoyable and motivating.[16]

Ivory et al[17] demonstrated that young adults do not believe that PLD use puts them at risk for auditory damage. Among the adolescents surveyed, 45% were unaware that output-limiting software can be downloaded on some brands of PLDs, and 75% were unaware that some PLD manufacturers have websites to educate their customers regarding safe listening practices. When they were made aware of these, only 56% reported that they would utilise such resources.

Furthermore, studies investigating PLD use by young college students reported that most respondents stated using their devices at safe listening levels or medium volume levels.[18,19] The participants in Danhauer et al's[18] study declared that they used higher volume settings in the presence of background noise. Similar findings were illustrated by Hoover and Krishnamurti:[19] two-thirds of their respondents reported using their PLDs for less than two hours at safe volume levels, while one-third reported occasionally using their devices at maximum volume levels.

In the Middle East, research on the awareness and use of PLDs or noise-induced hearing loss has been limited to a few studies in Saudi Arabia,[20–22] Egypt,[6] Jordan[23] and Oman.[24] These had results that were similar to those reported in the literature, although there were some expected discrepancies due to differences in the diverse questionnaires used.

For example, Al-Yahya et al[22] revealed that half of their participants had poor knowledge related to PLD use and the health risks associated with PLD use. Poor knowledge of hearing loss was also reported by Alzahrani et al[21] and Alnuman and Ghnimat.[23] Alzhrani et al[20] documented a high prevalence of hearing loss in listeners accustomed to using their devices at high volume levels but also good awareness among their participants of lowering their PLDs' volume to protect against hearing loss. Good hearing practices were also catalogued by Khandekar et al.[24] All these studies recommended that regulators should focus on increasing knowledge and education to improve practices related to noise-induced hearing loss. However, none of these studies looked in depth about the use of the PLDs and none of these studies estimated the noise exposure from the PLDs.

Awareness of hearing loss was investigated by Chung et al[25] using a web-based survey, which showed that only 8% of the participants considered hearing loss to be a significant problem, indicating low priority in comparison to other health issues, such as depression and sexually transmitted diseases. A follow-up study conducted five years later marked an increase to 30% and concluded that education on hearing loss could increase adults' likelihood of using hearing protectors.[26]

People seek and enjoy loud sounds due to auditory adaptation.[27] Playing music loudly is related to a heightened emotional response, episodic memory of events and cognitive appraisal of music. However, habits and activities differ between younger and older adolescents; for example, younger adolescents use PLDs, while older adolescents' activities include attending events with loud music, such as concerts and discotheques.[15]

The association between the onset of tinnitus and recreational noise exposure has been documented, reports show that about two thirds of the respondents report transient tinnitus after leisure noise exposure and 6.6% experienced chronic tinnitus.[28] Similarly, approximately 89.5% of the students had experienced transient tinnitus after loud music exposure

that was transient while 14.8% reported permanent tinnitus.[29] Tinnitus was observed in 28% MP3 users in comparison to 8% of non-users.[30]

The use of hearing protection devices should be encouraged among the younger generation, who frequently attend concerts or events with loud music. Several surveys have been conducted to evaluate the number of people who use hearing protectors, and it has ranged from 6% to 14%,[21,23,25] clearly indicating that awareness of the impact of noise on hearing is low.

While occupational regulations mandate that employees use hearing protectors in noisy environments and adhere to the National Institute for Occupational Safety and Health guideline of 85 decibels (dB) of exposure for an eight-hour working day, unfortunately, this is not reflected in the recreational environment. The European Commission has mandated that for new devices, output levels should be set to a standard of 85 dB, effective as of 2013.[31] They should also warn the user before increasing the level to 100 dB, but this feature is not available on all mobile phones, and even if it is, the user can switch it off or ignore it. PLDs set to the maximum loudness level can produce about 136 decibels of sound pressure level (dB SPL).[32,33]

Portnuff et al[34] evaluated the self-report and long-term measurement of MP3 player and reported that when measured with dosimeter 16.7% of their participants exceeded the 100% exposure limit compared to 14.3% reported exceeding the 100% exposure limit. They concluded that self-report can provide useful research or clinical tool for noise exposure estimate.

This study is novel due to its comprehensive analysis of personal listening device (PLD) usage, detailed demographic insights, and comparison of listening habits across age groups. It uniquely estimates self-reported noise exposure levels and examines awareness of hearing protection among young adults. By focusing on specific auditory health issues like tinnitus and hearing threshold shift and considering both environmental and PLD-related noise exposure, the study provides a holistic view of auditory risks. Additionally, it contributes valuable region-specific data to the limited research on PLD use and noise-induced hearing loss in the Middle East.

Aims and Objectives

This survey aims to investigate the perceptions and usage patterns of personal listening devices (PLDs) among young adults, alongside their knowledge of NIHL and its prevention through hearing protectors, in the context of both environmental and PLD-related noise exposure. The results from this study can shed light on the preventable risks young adults are subjected to and the potential hazards associated with loud music listening.

Objectives of the Study

The objectives of this study were as follows:

- To collect comprehensive demographic data, encompassing age, residence, occupation, hearing evaluation and hobbies, with a focus on activities involving exposure to loud music to better understand and assess the potential impact on auditory health and lifestyle choices.
- To investigate PLD behaviours and settings, including headphone usage patterns, daily and weekly durations of use and types of devices utilised to gain insights into individual audio consumption habits and preferences.
- To assess listening habits in terms of hours of use and weekly use of PLDs by young adults (18–23 years old) compared with adults (24–40 years old).
- To investigate the possible determinants impacting PLD use in young adults and the associated tinnitus.
- To estimate the self-reported noise exposure levels of young adults from self-reported PLD use.
- To examine self-reported listening behaviors and their perceived impact on hearing, and to infer whether there are differences between various age groups in these aspects.
- To explore the knowledge of young adults about protective listening devices.

Materials and Methods

An online form was utilised to provide participants with the project details. They were asked to indicate their consent by clicking a tab. Upon consent, the questionnaire opened for completion. If a participant declined consent, the

questionnaire closed, and a thank-you message appeared. Participants were informed in the information sheet that they could opt out of the survey at any point by closing the link and that their responses would not be saved. The survey typically took around 10 minutes to complete.

The Institutional Review Board of the University of Jordan approved this study under approval number 26–2022. It complies with the guidelines stated in the Declaration of Helsinki.

Participants

A cross-sectional survey design was used in this study, and the data were collected using a convenience sampling method. The participants were invited through social media platforms, such as MS Teams, WhatsApp and Facebook. The survey was open for six months (June to December 2022), and most of the responses came from the first two months of the survey's publication.

The survey was answered by 274 participants, and those between the ages of 18 to 40 years were invited to answer the questionnaire. The average age of the participants was 24.2 years (standard deviation [SD] = 5.1 years). Based on age, the participants were grouped into two categories: (1) young adults aged 18–23 years (151 participants) and (2) adults aged 24–40 years (123 participants). The calculation of noise exposure in a 40 hour week ($L_{ex,\ 40h}$) aimed to explore the average exposure of sound based on the self-reported volume setting.

Questionnaire

To examine the participants' listening habits, a questionnaire was developed in the Arabic language. This was due to the lack of availability of a comprehensive Arabic tool. The questionnaire explored the frequency of PLD use, the perceived effect of hearing loss, knowledge about hearing protection and the presence of associated tinnitus.

The questionnaire was piloted to check the language and understandability of the questions. Sixteen university students were asked to fill out the questionnaire and evaluate the clarity of the questions, as well as whether any modifications were required. The results from the pilot study were not included in the final analysis because new sections were added, and some questions were modified accordingly.

Most of the questions were answered in a closed format, except for some that required the answer to be in an open format. The questionnaire was distributed electronically through Google Forms and included the following domains:

- Demographic information: age, residence, occupation, hearing evaluation and hobbies, including listening to loud music.
- PLD behaviours and settings: headphone use, duration per day, duration per week and type of device.
- Hearing changes and their views of the reasons for these change and different listening situations.
- Tinnitus and its characteristics.
- Knowledge and use of protective hearing devices.

Estimation of the Loudness Level

The SPLs of the PLDs were estimated according to the participants' self-reported device volume setting, duration of use per day and duration of use per week. The volume control categories in this study followed those described by Twardella et al.[35] However, four volume categories were used instead of six: (1) lower than 50%, equating to 70 dBA (negligible); (2) greater than or equal to 50%, equating to 77 dBA; (4) 75%, equating to 89.4 dBA; and (5) 100%, equating to 101.8 dBA. For example, if a person reports using their device at maximum level this would mean 101.8 dBA would be used in the equation. The noise exposure level based on 40 hours of listening per week was derived from the usual exposure level in dB SPL calculated from the reported use per week and volume setting. The formula used was the same as that used by Twardella et al[35]

$$L_{ex,\ 40h} = L_{Aeq,Te} + 10\ lg\ *\ (T_e/T_0).$$

Here, $L_{Aeq,\ Te}$ represents the usual SPL, T_e represents the time spent on PLDs in hours per week, and T_0 is the reference duration of 40 hours per week.

The participants were then grouped into two loudness categories: (1) listeners at low exposure levels, which included the participants who reported not using their devices and those with an estimated listening level of <80 dBA, and (2) listeners at high exposure levels, which included the participants with an estimated listening level of >80 dBA. The 80-dBA cut-off was based on the WHO (2015) recommendation of weekly exposure for adults, which is less than 80 dB for 40 hours per week.

Statistical Analysis

The results were analysed using the SPSS software v23 for Windows. Levene's test for equality of variances was not significant at >0.05, indicating that parametric tests should be performed. The data were analysed using univariate analysis of variance (ANOVA). The significance level was set at $p < 0.05$ (5%), with a 95% confidence interval. A least significant difference post-hoc exam was performed for multiple comparisons among the groups.

Results

Differences Between the Participants Based on Age

The participant's demographics are tabulated in Table 1. Residents of Amman, the capital of Jordan, comprised 70% of the participants, and their distributions based on age were similar (ie 39.6% for young adults and 31.1% for adults). The young adult category was composed of mainly undergraduate students (37%), while 28.9% of the participants in the adult age group were working; 13.9% of the total participants were unemployed. Most of the respondents in both age groups (46%) were either studying or working in a health-related field, such as medicine, allied health medicine and nutrition,

Table 1 Participant's Demographics Based on Age

	Young adults (18–23 years old)			Adults (24–40 years old)			Total	
	Count	%	$L_{ex,40h}$	Count	%	$L_{ex,40h}$	Count	%
	151	55.1	71.0	123	44.9	70.0	274	100
Residence								
Capital	108	39.6	73.0	85	31.1	71.2	193	70.7
Governates	24	8.8	64.0	13	4.8	72.6	37	13.6
International	18	6.6	69.8	25	9.2	64.8	43	15.8
Occupation								
Undergraduate	101	37.0	72.3	16	5.9	70.7	117	42.9
Postgraduate	3	1.1	72.7	9	3.3	69.7	12	4.4
Employed	27	9.9	70.4	79	28.9	70.1	106	38.8
Unemployed	19	7.0	66.2	19	7.0	69.1	38	13.9
Field								
Health-related	73	26.6	73.3	53	19.3	70.7	126	46.0
Scientific	33	12.0	67.0	22	8.0	70.4	55	20.1
Humanities	32	11.7	72.3	33	12.0	69.3	65	23.7
Not applicable	13	4.7	65.5	15	5.5	70.9	28	10.2
Hearing test								
Yes	66	24.2	69.5	68	24.9	70.4	134	49.1
No	84	30.8	72.5	55	20.1	69.5	139	50.9
Hobbies (loud sounds)								
Yes	94	34.6	76.9	52	19.1	77.4	146	53.7
No	54	19.9	61.9	71	26.1	64.6	125	46.0
Types of hobbies								
Listening to music	71	26.1	77.5	46	16.9	77.9	117	43.0
Playing a musical instrument	19	7.0	71.6	4	1.5	70.5	23	8.5
Hunting	1	0.4	91.8	0	0	–	1	0.4

Note: $L_{ex,40h}$ in dB.

and the difference between the groups was not statistically significant. The rest were distributed between scientific fields (eg engineering and physics, 20.4%) and the humanities (eg human resources and education, 23.4%).

On average, the respondents living in the capital had a higher estimation of noise exposure (72.3 dBA) compared with those residing in the governorates (67.0 dBA) or abroad (66.9 dBA). The participants were also asked whether they had a previous formal hearing evaluation. Positive responses were noted from 134 participants (49.1%), comprising 24.2% young adults and 24.9% adults. Five of these participants (1.8%) reported having mild hearing loss, and four (1.5%) reported having moderate hearing loss. Seventy-two (54%) of these participants were either studying or working in a health-related field.

Multivariate ANOVA was conducted with $L_{ex,\ 40h.}$ Age was the dependent variable, whereas occupation, residence and field were the fixed variables. Normality and homogeneity of variance tests indicated that the data satisfied the assumptions for the ANOVA test. The results showed that the mean estimation of noise exposure was not significantly different between the groups.

Approximately 53.7% of the participants reported engaging in hobbies involving loud sounds. Among them, 34.6% were young adults (18–23 years old), while 19.1% were classified as adults (24–40 years old). The results from the one-way ANOVA showed statistical significance ($F(2, 269) = 6.766$, $p = 0.001$). The R-squared value suggested that 4.8% of certain hobbies depend on age and differ between age groups (adjusted R-squared = 4.1%). These hobbies included listening to loud music (43%) and playing a musical instrument (8.5%). Interestingly, only one participant in the young adult category listed hunting as their hobby (0.4%).

Differences Between the Participants Based on Loudness Estimation

Next, the results were investigated based on the estimation of exposure to sound, and the participants were divided into two groups: (1) PLD users with low exposure levels, including the participants with a calculated $L_{ex,\ 40h}$ of <80 dBA, and (2) PLD users with high exposure levels, which included the participants with a calculated $L_{ex,\ 40h}$ of >80 dBA.

The distribution of the participants based on noise level estimation and the demographic findings is listed in Table 2. 28.5% of the participants listened to their devices at levels that exceeded 80 dB (mean [M] = 89.9). Furthermore, 196 participants (71.5%) were categorized as having low exposure levels, while 78 (28.5%) were classified as having high exposure levels. The contrast between these groups was statistically significant, with the low exposure group averaging 62.9 dB SPL (SD = 10.2) compared with an average of 89.9 dB SPL (SD = 5.9) for the high exposure group ($t(272) = -21.7$, $p < 0.001$).

Among these participants, 23 individuals had exposure levels between 80 and 85 dBA (M = 81.8, SD = 2.1), 17 had exposure levels between 85 and 90 dBA (M = 87.4, SD=1.2), and 35 had exposure levels exceeding 90 dBA (M = 95.6, SD = 3.0). The distinction between the low-exposure group and all levels of high exposure was statistically significant. Moreover, the comparison between the participants with high exposure levels and those with low exposure levels was significantly different in all categories, as indicated by the asterisks in Table 2.

Table 2 shows the distribution of the participants based on the $L_{ex,\ 40h}$ calculation. Most of the participants (37%) who reported that they had their hearing formally evaluated were in the low exposure category (N 101) in comparison to 12.1% of the participants in the high exposure category (N 33). Additionally, 23.9% of the total participants who reported having hobbies that involved loud sounds had a high exposure level of 90.5 dB.

Habits of Using PLDs

Three-quarters of the respondents (198, 73.1%) stated that they owned a PLD used for recreational purposes. Young adults constituted 116 (42.8%), while the adults were 82 (30.3%). One-way ANOVA was statistically significant ($F(1, 269) = 4.729$, $p = 0.031$), indicating that the young adults were more likely to own a PLD in comparison to the adults. The R-squared value established that approximately 1.7% of the variance in age could be explained by having a PLD for recreational use (adjusted R-squared = 1.4%). Similar responses were obtained from the two age groups regarding the use of headphones with PLDs, and the difference was not statistically significant at $p > 0.05$. Mobile phones were used as the only device for listening to music by 47.6% of the respondents, whereas 18.5% reported using multiple devices that included mobile phones, computers and tablets.

Table 2 Participants' Demographics Based on the Estimated $L_{ex,\ 40h}$

	Low			High			Total	
	Count	%	$L_{ex,40h}$	Count	%	$L_{ex,40h}$	Count	%
	196	71.5	62.9	78	28.5	89.9*	274	100
Age								
18–23 years old	104	38.0	62.6	47	17.2	89.7*	151	55.1
23–40 years old	92	33.6	63.2	31	11.3	90.1*	123	44.9
Residence								
Capital	130	47.7	63.6	63	23.1	89.9*	193	70.3
Governates	29	10.6	60.5	8	2.9	90.7*	37	13.6
International	36	13.2	62.6	7	2.6	88.6*	43	15.8
Occupation								
Undergraduate	79	28.9	63.4	38	13.9	90.1*	117	42.9
Postgraduate	8	2.9	60.6	4	1.5	90.0*	12	4.4
Employed	76	27.8	62.5	30	11.0	89.6*	106	38.8
Unemployed	32	11.7	63.4	6	2.2	90.2*	38	13.9
Field								
Health-related	88	32.1	64.2	39	14.2	89.9*	126	46.4
Scientific	42	15.3	60.9	14	5.1	90.9*	55	20.4
Humanities	43	15.7	60.9	21	7.7	89.7*	65	23.4
Not applicable	23	8.4	64.9	4	1.5	88.1*	28	9.9
Hearing test								
Yes	101	37.0	63.1	33	12.1	90.9*	134	49.1
No	94	34.4	62.8	45	16.5	89.1*	139	50.9
Hobbies (loud sounds)								
Yes	81	29.8	66.3	65	23.9	90.5*	146	53.7
No	113	41.6	60.7	13	4.8	86.7*	126	46.4
Types of hobbies								
Listening to music	61	42.3	65.4	56	20.6	91.0*	117	43.0
Playing a musical instrument	18	6.6	66.8	5	1.8	87.7*	23	8.5
Hunting	0	0	0	1	0.4	91.8	1	0.4

Notes: $L_{ex,40h}$ in dB. *Significant difference $p < 0.05$.

About half of the respondents (52.9%) reported that their devices provide a warning message when the volume is increased to a certain level; these responses were similar for the two age groups ($p > 0.05$). 27.0% reported that their devices did not give a warning signal when increasing the volume and 20.4% were the non-users who did not answer this question. A follow-up question was asked to the participants who answered yes to the warning signal, The question asked if they ignored the warning and increased the volume beyond that of the warning, The responses were "sometimes" (24.1%), "yes" (19%), while 13.5% replied "no". The responses were similar for the two age groups.

The participants were then asked about the volume setting on their devices. A total of 45 participants (16.5%) reported using their devices at the maximum volume: 55.5% of them were young adults, while 44.5% were adults. Eighty individuals (29.4%) reported using their devices at three-quarters to the maximum point, 53.75% were young adults compared to 46.25% adults (Figure 1A)

(Figure 1B) shows the participants' distribution based on the $L_{ex,\ 40h}$ calculation. As the time spent on the device and the volume setting both contribute to the calculation of the noise exposure the general trends showed that respondents who reported setting the volume to the maximum point and spent more hours on their devices per week tended to have higher noise exposure estimates.

The evaluation of the duration of headphone use per week showed that 28.8% of the respondents reported using their devices daily, and 32.4% reported using their devices once a week. The rest stated that they used their devices every two

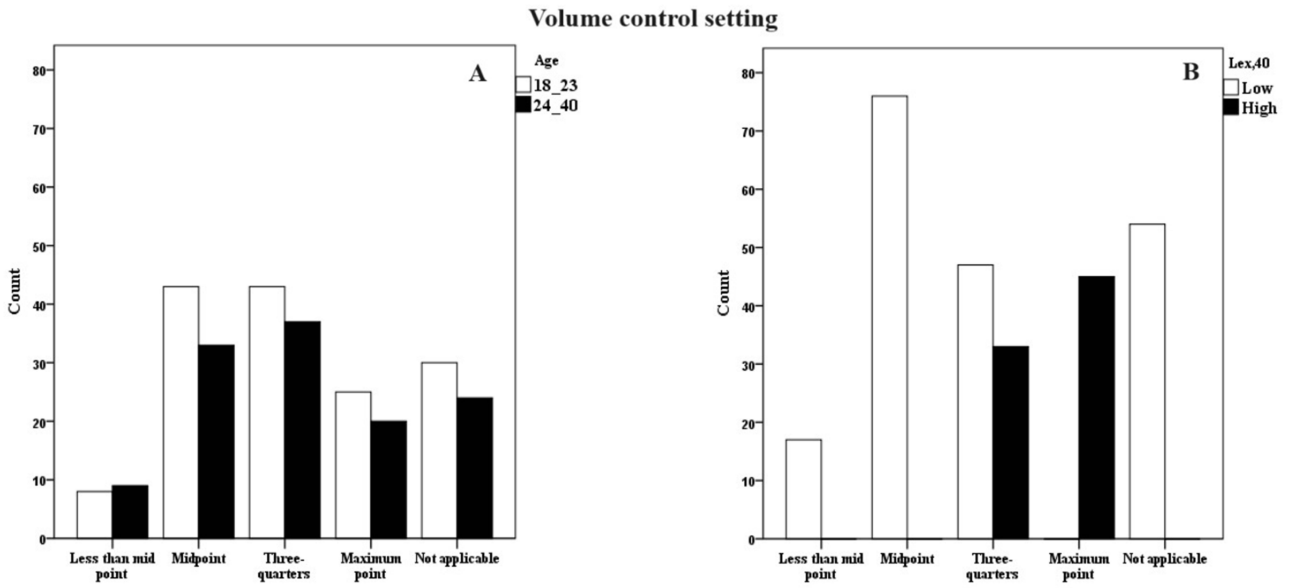

Figure 1 Volume control setting as a function of age (**A**) and Lex,40h (**B**).

days (23.3%) or once every four days (15.5%). (Figure 2A) shows the trend of participants' responses: the young adults were more likely to use their devices daily, while the adults were more likely to use their headphones once a week.

ANOVA was conducted to examine the relationship between headphone use per week and age. Headphone use per week was found to be a significant predictor of age ($F(3, 215) = 3.080$, $p = 0.028$), accounting for approximately 4.1% of the variance in age. Bonferroni-corrected pairwise comparisons confirmed these findings, as there was a significant difference in mean age between the participants who reported using headphones once a week compared with those who reported using headphones daily (mean difference [Mdiff] = −0.2423, standard error [SE] = 0.08513, $p = 0.029$) and

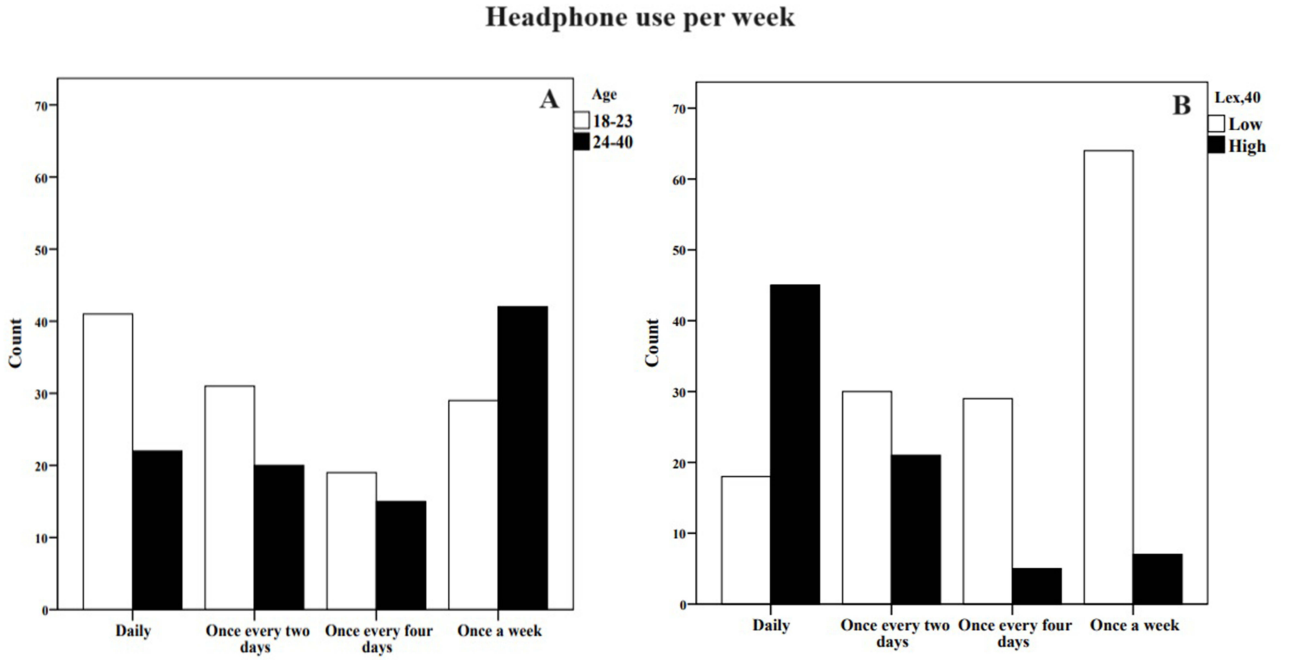

Figure 2 Headphone use per week as a function of age (**A**) and calculated exposure (**B**).

between those who reported using headphones once a week compared with those who reported using headphones once every two days (Mdiff = −0.1994, SE = 0.09028, p = 0.170).

(Figure 2B) show the distribution of the responses based on the calculation of the noise exposure, because the resultant exposure level is dependent on both the time spent on the device and the volume level it can also be observed that if a participant used their device once a week at maximum volume, they still had a high calculation of exposure. Furthermore, 49.1% of the respondents reported using their headphones less than an hour per day, 21.6% reported using their headphones for two hours per day, and 10% reported using their headphones for over three hours per day. The distribution based on age was similar between the two age groups (Figure 3A and B).

Sixty-three individuals (28.8%) indicated daily usage of their devices and exhibited an average $L_{ex,40h}$ of 85.2 dBA. Among this group, the majority, comprising 48 respondents (76.2%), used their devices for more than two hours, and 45 (71.4%) set the volume control at three-quarters to maximum volume. Additionally, 45 individuals (71.4%) fell into the high exposure group, with 41 respondents (65.1%) categorised as young adults.

Those who reported that when they used their PLDs with headphones, the sound was audible to a person sitting next to them made up 43.8%, with 26.5% from the young adult group and 17.4% from the adult group (p > 0.05).

Those who reported that when they listened to their PLDs and wanted to engage in conversation, they had to raise their voices comprised 56%; 30.8% were in the young adult group, while 25.3% were in the adult group (p > 0.05).

General Knowledge and Habits

Table 3 shows the participants' responses regarding their behaviours and beliefs about the use of PLDs, with the $L_{ex,40h}$ calculation for each question as a function of age. Most respondents (96.3%) believed that listening through headphones negatively impacted hearing. However, their actions were contrary to this.

When asked about music enjoyment, 59.8% of the respondents revealed that they did not enjoy listening to music at low volume levels. The average $L_{ex,40h}$ for these participants was around 80 dBA, in comparison to 40.2% who reported that they enjoyed listening to music at low volume levels, with a $L_{ex,40h}$ calculation of about 70 dBA.

Around 71% of the respondents agreed that it was possible to suffer from hearing loss at a young age: 103 (37.9%) young adults and 90 (33.1%) adults. Those who answered "maybe" constituted 23.9%, and those who did not believe it was possible were 4.8%. Similarly, when asked about their perception of whether they were at risk of hearing loss at their current age, 30.1% believed they were not. The difference based on age was not significant.

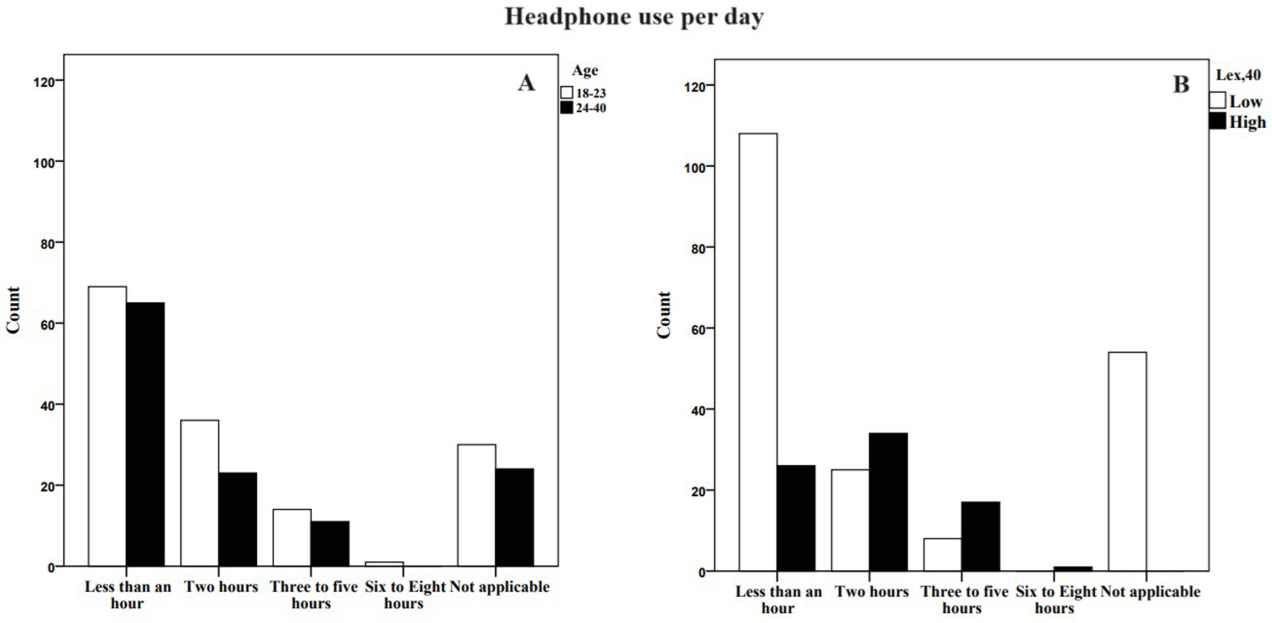

Figure 3 Duration of time spent on personal listening devices, in hours, as a function of age (**A**) and Lex,40h (**B**).

Table 3 Participants' Responses Regarding General Knowledge and Habits

	Young adults (18–23 years old)			*Adults (24–40 years old)*			*Total*		
	Yes* (%) $L_{ex,40h}$ *SD	***No* (%) $L_{ex,40h}$ *SD***	***Maybe* (%) $L_{ex,40h}$ *SD***	***Yes* (%) $L_{ex,40h}$ *SD***	***No* (%) $L_{ex,40h}$ *SD***	***Maybe* (%) $L_{ex,40h}$ *SD***	***Yes* (%) $L_{ex,40h}$ *SD***	***No* (%) $L_{ex,40h}$ *SD***	***Maybe* (%) $L_{ex,40h}$ *SD***
Music enjoyment at low levels	45 *(20.5)* **69.7** *11.1*	75 *(34.2)* **80.6** *11.8*		43 *(19.6)* **70.2** *11.3*	56 *(25.6)* **78.5** *12.4*		88 *(40.2)* **69.9** *11.1*	131 *(59.8)* **79.9** *12.0*	
Can listening to music through headphones have a negative impact on hearing?	143 *(52.6)* **71.8** *15.5*	6 *(2.2)* **59.0** *4.4*		119 *(43.8)* **69.8** *15.2*	4 *(1.5)* **75.6** *4.5*		262 *(96.3)* **70.9** *15.4*	10 *(3.7)* **65.6** *9.5*	
Is it possible to have hearing loss at a young age?	103 *(37.9)* **72.6** *14.6*	11 *(4.0)* **69.3** *19.7*	34 *(12.5)* **68.7** *16.4*	90 *(33.1)* **69.3** *14.7*	2 *(0.7)* **91.2** *00*	31 *(11.4)* **70.7** *15.4*	193 *(71.0)* **71.1** *14.7*	13 *(4.8)* **72.8** *19.8*	65 *(24.2)* **69.6** *15.8*
Is having good hearing important?	146 *(53.9)* **71.5** *15.4*	2 *(0.7)* **67.4** *24.6*		123 *(45.4)* **70.0** *15.0*	0 *(0)* **–**		269 *(99.3)* **70.8** *15.2*	2 *(0.7)* **67.4** *24.6*	
Do you know anyone who has hearing loss?	103 *(37.9)* **71.8** *15.1*	46 *(16.9)* **69.3** *16.2*		87 *(32.0)* **70.0** *14.4*	36 *(13.2)* **69.9** *16.5*		190 *(69.9)* **71.2** *14.8*	82 *(30.1)* **69.6** *16.2*	
Are you at risk of hearing loss?	103 *(37.9)* **69.6** *14.8*	46 *(16.9)* **75.2** *16.3*		87 *(32.0)* **70.4** *15.1*	36 *(13.2)* **69.0** *14.8*		190 *(69.9)* **70.0** *14.9*	82 *(30.1)* **72.4** *15.9*	
Does it worry you that you may get hearing loss?	83 *(30.5)* **72.2** *15.7*	66 *(24.3)* **70.2** *15.2*		57 *(21.0)* **70.8** *15.4*	66 *(24.3)* **69.3** *14.7*		140 *(51.5)* **71.6** *15.5*	132 *(48.8)* **69.8** *14.9*	

Abbreviations: SD, Standard Deviation of the $L_{ex,40h}$.

ANOVA was conducted to explore the relationship between hearing-related variables and the dependent variable, age. Notably, the results revealed a non-significant overall effect ($F(15, 256) = 1.113$, $p = 0.345$), with a corrected model accounting for approximately 6.1% of the variance in age.

When the participants were asked whether they were worried that they may have hearing loss at a young age, about half said they were worried (140), and about half reported that they had experienced worsening hearing previously. Sixty-eight of them stated that they did not enjoy music at low volume levels. Twenty-seven used their devices at the maximum level, 38 used their PLDs daily, and 14 used their devices three to five hours per day. Furthermore, whether these participants make conscious decisions when using their PLDs was explored, resulting in an average $L_{ex,40h}$ of 71.6 dB.

Ninety-nine participants who expressed that they were worried about hearing loss had a low calculation of $L_{ex,40h,}$ while 41 had a high calculation, favouring the notion that they were making conscious decisions about their devices' volume control.

The young adults were more likely to use their PLDs at loud levels when they wanted to enjoy listening to music, while the adults were more likely to do the same when they exercised. The response trends are displayed in Figure 4.

The respondents reported that their source of information were primarily lectures (59.3%), followed by social media (53.5%), television (26.6%), physicians (23.2%) and other sources, including parents et al (11.2%).

Hearing Difficulties and Self-Reported Threshold Shift

Whether the participants experienced hearing difficulties in quiet situations, such as watching television or in a restaurant, loud situations, such as parties or raves, or after attending parties or raves was also explored, as this could indicate a temporary threshold shift. Figure 5 shows the participants' responses as a function of age. Similar trends were observed among the two age groups, with the highest reported difficulty experienced when attending parties or raves.

Ninety-one (33.5%) participants reported that at some stage in their lives, they experienced worsening in their hearing thresholds; 20.2% were young adults, while 13.2% were adults. The univariate ANOVA was not statistically significant

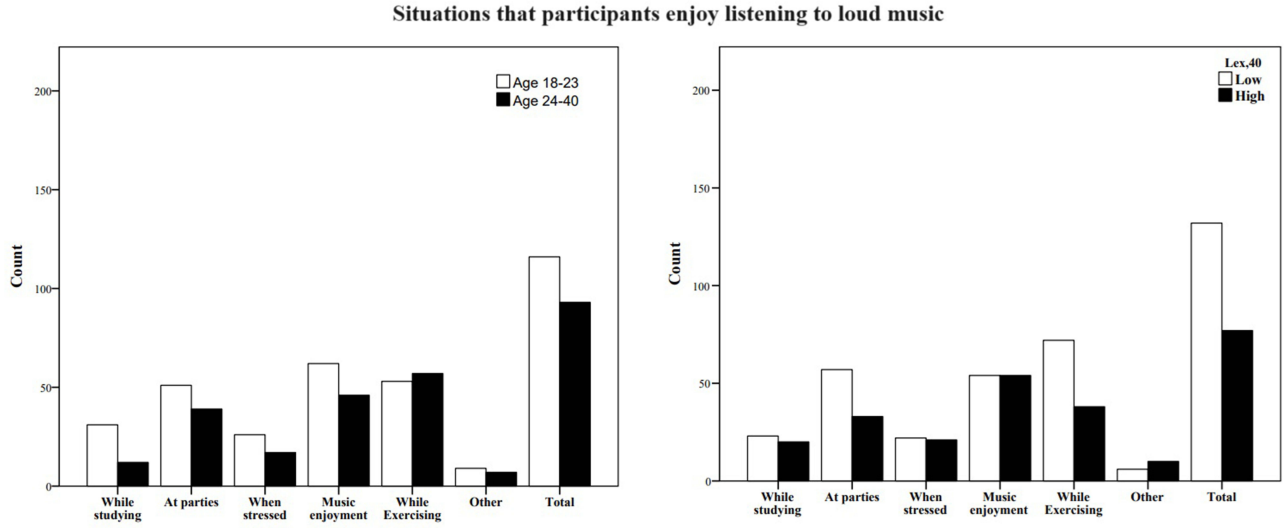

Figure 4 Situations wherein listening to loud music is enjoyed as a function of age (left) and Lex,40h (right).

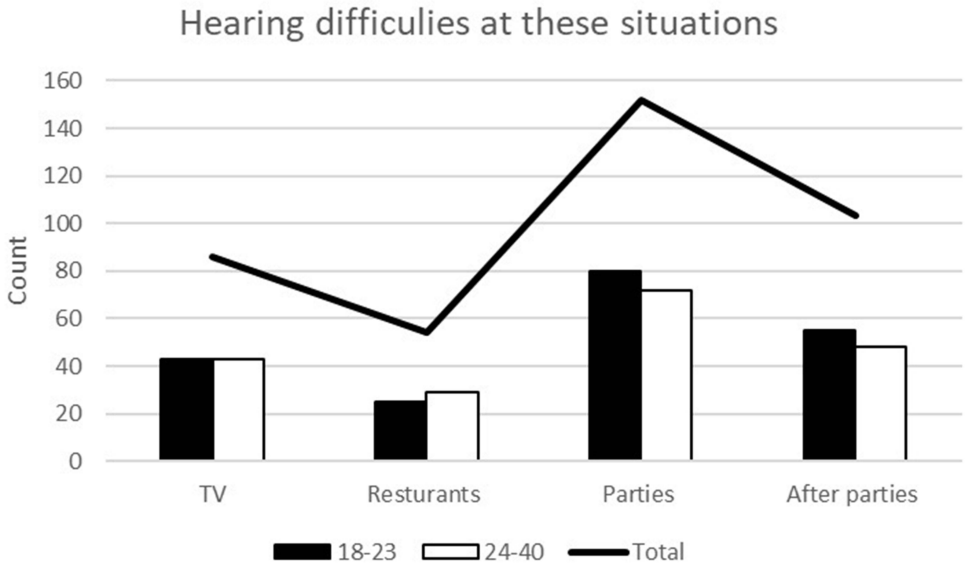

Figure 5 Situations wherein participants report hearing difficulties as a function of age.

($p > 0.05$). Sixty-four (23.5%) were in the low exposure group, and 27 (9.9%) were in the high exposure group. The difference between the groups based on exposure was not statistically significant. Fifty-eight (23.6%) thought that loud music was the reason for this shift in their thresholds, followed by 16.3% who believed that ear infections were the cause.

Those who said that their hearing returned to normal within two hours comprised 12.3%, followed by 11.9% on the same day, 9.9% after a week and 7.5% within two days. Ultimately, 5.9% reported that their hearing did not return to normal. Additionally, 21.3% disclosed that they informed another person that their hearing was affected, such as their parents (6.1%), an audiologist (5.7%), a friend (4.8%) or a physician (4.8%).

Tinnitus

Ninety-seven respondents (35.4%) reported experiencing tinnitus at some stage of their lives, with 24.6% stating that they heard it in both ears. Tinnitus was described to be transient by most of the participants, lasting for less than two hours (35.1%). Among the respondents who said they had tinnitus, 2.4% narrated that they heard it all day.

One-way ANOVA was conducted to compare the effect of having tinnitus on the values of $L_{ex,40h.}$ The mean $L_{ex,40h}$ for the participants who reported that they had tinnitus was 73.4 dB (SD = 16.5) in comparison to 69.0 dB (SD = 14.4) for those who did not report having tinnitus. The difference was statistically significant ($F(1, 272) = 5.3$, $p = 0.02$).

The overall percentage of participants who answered "yes" to having tinnitus with low exposure was 21.9% in comparison to 13.5% with high exposure. However, only one participant, a young adult, in the low exposure group reported that the tinnitus lasted all day, compared with five participants in the high exposure group (four young adults and one adult). The $L_{ex,40h}$ evaluation for the participants who reported having tinnitus all day showed that the four participants in the young adult group had an average $L_{ex,40h}$ of 93.9 dB (SD = 5.5) in comparison to 79.1 dB (SD = 8.0) for the adults. This difference was marginally statistically significant in an independent sample *t*-test ($t(4) = 2.7$, $p = 0.05$).

Most of the participants (24.5%) recounted that their tinnitus sounded like hissing (/s/, /z/), while the rest reported it as pulsatile (8%) or whooshing (6.8%). When asked whether they were worried about their tinnitus, 17.2% reported that they were worried, with 3.6% declaring that they felt very worried.

Hearing Protectors

The survey participants were asked about knowledge, usefulness and usage of hearing protectors. A striking majority said that they were aware of hearing protectors (94.1%) and that they believed hearing protectors were useful (90.4%). However, when asked whether they had ever used hearing protection, only 20.7% reported that they had, 12.2% of those

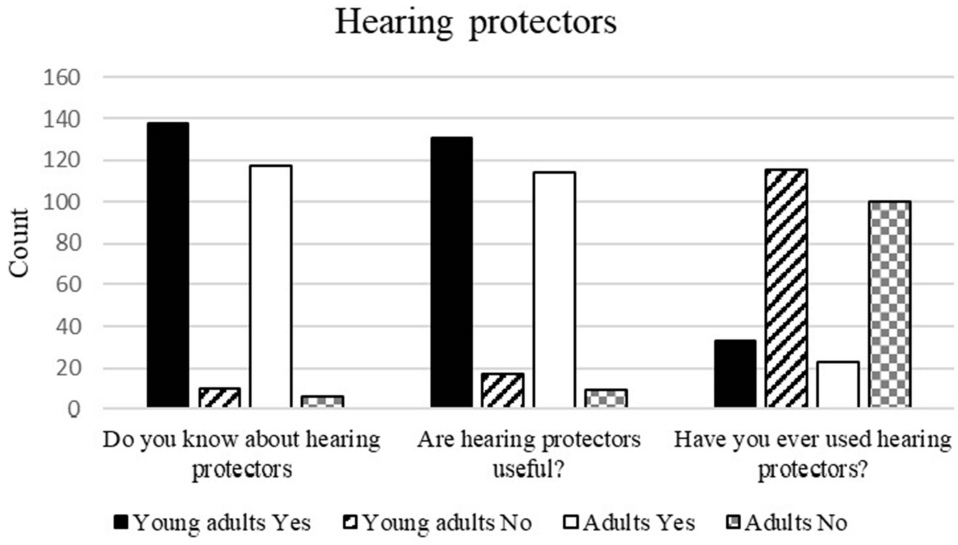

Figure 6 Knowledge and use of hearing protectors based on the age of the participants.

who used hearing protectors were in the young adult group, compared with 8.5% in the adult group. Figure 6 shows the participants' responses based on age category. Reverse trends for the participants are evident between knowledge and practice.

Discussion

The current survey aimed to shed the light on the young adults and their general knowledge and habits regarding noise exposure and use of PLDs. The participants were grouped according to two categories: age and exposure calculation. Based on the analysis of the results, there were no differences based on age in most of the aspects except for hobbies, where the young adults were more likely to engage in hobbies with loud sounds, while the adults were less likely to do so. This was expected, as the young adults had more free time compared to the adults, who had more work responsibilities. However, viewing the results based on exposure estimation revealed major differences.

Regarding habits of using PLDs, about three-quarters of the participants reported that they owned a PLD that they used for recreational purposes, with 47% commenting that mobile phones were their main device, and 18.5% using a combination of phones, computers and tablets. These findings were consistent with reports in the literature[36] and technological advancements in mobile phone manufacturing.

According to regulations set by the European Committee for Electrotechnical Standardization, all electronic devices capable of media playback sold after February 2013 must have a default maximum output volume level of 85 dB[31] and provide a warning message if the volume level is increased. In the current study, 52.9% of the respondents said that this feature was available on their phones, but 24.1% admitted that sometimes they ignored the message, and 19% tended to always ignore the message. Interestingly, around 48% were not aware of this feature on their devices because it could be disabled, which was consistent with Ivory et al.[17]

Studies that measured the noise exposure levels in their participants are limited due to technical and logistic difficulties for example equipment required, duration of use, type of content used (eg music genre, speech). This limitation is associated with all of the measurements whether it was self-reports or actual measurements. A recent Apple Hearing study[37] attempted to overcome these limitations. The study reported that about 10% of their 200 thousand participants exceeded the 80 dB exposure limit recommended by the world health organisation. While the results of this study is invaluable and novel it was limited to one type of device and its accessories which may not be feasible less developed countries.

Among those surveyed, 29.4% used their devices at three-quarters to the maximum level, and 16.5% used their devices at the maximum level. Regarding duration, 28% used their devices daily, 23.3% used their devices thrice a week, and 31.6% used their devices less than two hours per day. These findings were consistent with Catalano and Levin,[38] who reported that 31.4% of their study's participants exceeded the maximum allowable duration permitted. Similarly, Al-Yahya et al[22] reported that 43.1% of their participants used their devices more than four days a week.

Further investigation of the participants who used their PLDs daily showed that they had a high noise exposure calculation mean $L_{ex,40h}$ of 85.2 dBA. Forty-eight individuals (76.2%) used their devices for more than two hours, 45 (71.4%) placed the volume control at three-quarters to the maximum volume, 45 (71.4) were in the high exposure group and 41 (65.1%) were young adults. This suggests that consistent use of PLDs can negatively impact hearing with persistent use.[33]

While the young adults and adults seemed to perform similarly in terms of their habits and use of PLDs, the exposure calculation was more important to show differences in attitudes and performance. The participants who listened to their devices at high levels were less likely to take care of their hearing and have their hearing formally evaluated, and they engaged in hobbies involving loud sounds.

An identified gap between knowledge and practice revealed that education should be formally implemented at schools and universities and on social media. Many of the questions in this questionnaire addressed the participants' knowledge regarding PLD use. Looking at the results on their own showed that knowledge was high – for example, the participants reported that listening to music through headphones could have a negative impact on hearing (96.3%), that they believed hearing was important (99.3) and that they may be at risk of hearing loss (69.9%).

However, the application of this knowledge to their PLD activities showed a discrepancy between knowledge and habits, as around 60% stated that they did not enjoy music at low volume levels, and about 28.5% had a high $L_{ex,40h}$ calculation. Hutchinson Marron et al[39] concluded that

> despite reported knowledge of hearing loss risk due to PLD use in virtually all college students, one in four were found to listen to their PLDs at free-field equivalent levels greater than 80 dBA.

This was consistent with the conditioning, adaptation and acculturation to loud music (CAALM) model, which connects loud music to enjoyment in certain situations. The model proposes that people who are exposed to loud music become conditioned to enjoy loud sounds over time. "Exposure to loud sound also causes adaptation within the auditory system, so there is both a desire for, and tolerance of, loud sound during leisure time".[27]

The association between noise exposure and tinnitus has been established.[28,40–42] In this study, transient tinnitus was reported by 35.4% of the respondents, while persistent tinnitus was reported by 2.4%. Moller[7] asserted that tinnitus affects 1.4–9.8% of young adults aged 20–29 years. Other studies have demonstrated that the prevalence of tinnitus after noise exposure ranges between 14.8 and 37%.[29,43,44] This variation in the findings can be explained by the way tinnitus is defined.

The current survey illustrated that only 20.7% of the participants used ear protectors even though 94.1% reported that they were aware of hearing protectors, and 90.4% mentioned that they thought hearing protectors were useful. A large-scale web survey with 9693 respondents reported that only 14% used hearing protectors in situations where they believed the music was too loud.[25] Furthermore, only 9.8% of 250 university students in Alnuman and Ghnimat's[23] study reported using hearing protectors, while 94% of Saudis in Alzahrani et al's[21] research admitted to never using hearing protectors.

Limitations of the current study

The estimates of exposure may be exaggerated or underestimated, as they relied on the participants' responses and were not directly measured. The estimations of the time spent and sound levels on PLDs were also approximations and could potentially differ from day to day. In addition, the types of hearing protectors were not investigated in the study.

Conclusion

The findings of this study revealed that about one-third of the participants were exposed to very high levels of noise from their PLDs, which could be associated with their hobbies and activities. About half of them did not recall whether they ever had a formal hearing evaluation, which is an indication that formal hearing evaluation should be mandated for adults to protect them from future damage to their hearing.

The study also showed a gap between the knowledge of the participants and their practices. This was clear through their high knowledge of hearing protectors and their low use of them. This highlights the importance of increasing awareness and education of hearing and its protection.

Most of the young adults reported that they obtained their information from social media or lectures, and this should be emphasised in future campaigns to raise awareness about the harmful effects of loud sounds on hearing.

Disclosure

The authors report no conflicts of interest in this work.

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