A PURE TONE AUDIOMETRY STUDY OF HEARING LOSS USING AIR CONDUCTION AND BONE CONDUCTION ASSESSMENT AMONG YOUNG ADULTS IN JOHOR

NOOR HIDAYAH BINTI JAAFAR

SULTAN IDRIS EDUCATION UNVERSITY

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ABSTRACT

The research examined the frequency of hearing loss among college students in Johor via the use of pure tone audiometry (PTA) screening tests. The study included a sample of 30 participants between the ages of 18 and 35, with 46.67% of them using personal listening devices (PLDs) for educational reasons. The Air Conduction (AC) and Bone Conduction (BC) tests were used to evaluate the different types and levels of hearing impairment by using Audiometer, model Interacoustic AD629. This research used one (1) decibel (dB) increment for the up-and-down hearing threshold for both AC and BC measurements. The participants were categorized into two groups: the experimental group, which altered noise thresholds and daily use, and the control group, which kept their usual use of PLDs. The findings indicated that 73.33% of young adults use PLDs, with earphones being the predominant preference. Approximately 30% of the whole amount is comprised of cellphones and laptops. A substantial number of participants use them while sleeping, probably improving hearing sharpness and thresholds in young individuals. The study's findings were assessed using the Statistical Package for the Social Sciences (SPSS) and paired t-tests. The findings indicated that there were no significant changes in the air-bone gap for both ears in the control group at frequencies of 1500 Hz and 2000 Hz. Nevertheless, significant changes were noted at frequencies of 250 Hz, 500 Hz, 3000 Hz, and 4000 Hz, but there were no substantial variations in auditory perception before or after 1500 Hz. The study determined that the use of PLDs without regulating the time and volume settings may lead to auditory impairment and the emergence of Noise-Induced Hearing Loss (NIHL).

KAJIAN AUDIOMETRI NADA TULEN BAGI KEHILANGAN PENDENGARAN MENGGUNAKAN PENILAIAN KONDUKSI UDARA DAN KONDUKSI TULANG DI KALANGAN BELIA DI JOHOR

ABSTRAK

Penyelidikan ini mengkaji kekerapan kehilangan pendengaran dalam kalangan pelajar kolej di Johor melalui penggunaan ujian saringan audiometri nada tulen (PTA). Kajian itu termasuk sampel 30 peserta berumur antara 18 dan 35, dengan 46.67% daripada mereka menggunakan peranti pendengaran peribadi (PLD) untuk tujuan pendidikan. Penilaian Konduksi Udara (AC) dan Konduksi Tulang (BC) digunakan untuk menilai pelbagai jenis dan tahap kecacatan pendengaran dengan menggunakan Audiometer, model Interacoustic AD629. Penyelidikan ini menggunakan satu (1) kenaikan desibel (dB) untuk ambang pendengaran naik-turun untuk kedua-dua pengukuran AC dan BC. Para peserta dikategorikan kepada dua kumpulan: kumpulan eksperimen, yang mengubah ambang bunyi dan penggunaan harian, dan kumpulan kawalan, yang mengekalkan penggunaan biasa PLD mereka. Penemuan menunjukkan bahawa 73.33% belia menggunakan PLD, dengan fon telinga menjadi keutamaan utama. Kira-kira 30% daripada jumlah keseluruhan terdiri daripada telefon bimbit dan komputer riba. Sebilangan besar peserta menggunakannya semasa tidur, mungkin meningkatkan ketajaman pendengaran dan ambang pada individu muda. Dapatan kajian telah dinilai menggunakan Pakej Statistik untuk Sains Sosial (SPSS) dan ujian-t berpasangan. Penemuan menunjukkan bahawa tiada perubahan ketara dalam jurang udara-tulang bagi kedua-dua telinga dalam kumpulan kawalan pada frekuensi 1500 Hz dan 2000 Hz. Namun begitu, perubahan ketara telah diperhatikan pada frekuensi 250 Hz, 500 Hz, 3000 Hz, dan 4000 Hz, tetapi tidak terdapat variasi yang ketara dalam persepsi pendengaran sebelum atau selepas 1500 Hz. Kajian ini menentukan bahawa penggunaan PLD tanpa mengawal tetapan masa dan volum boleh menyebabkan gangguan pendengaran dan kemunculan Kehilangan Pendengaran Akibat Bunyi (NIHL).

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LIST OF ABBREVIATIONS

AC	Air Conduction
ANOVA	Analysis of Variance
BC	Bone Conduction
BMI	Body Mass Index
dB	Decibel
DOSH	Department of Occupational Safety and Health Malaysia
DPOAEs	Distortion Product Otoacoustic Emission
EHF	Extended Hearing Frequency
HL	Hearing Loss
Hz	Hertz
kHz	kiloHertz
NH	Normal Hearing
NIHL	Noise-Induced Hearing Loss
NIOSH	National Institute of Occupational Safety and Health
OSHA	Occupation Safety and Health Administration
PEL	Permissible Exposure Limit
PLD	Personal Listening Devices
PMP	Personal Music Player
PTA	Pure Tone Audiometry
REL	Recommended Exposure Limit
SNHL	Sensorineural Hearing Loss
SPSS	Statistical Package for the Social Sciences

TEOAEs	Transient Evoked Otoacoustic Emission
TWA	Time-Weighted Average
WHO	World Health Organization

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter provides an overview of the history of pure tone audiometry as it relates to diagnosing hearing loss in humans. The explanation of the issue explains the several elements that have a role in developing hearing loss in teenagers and young adults. Subsequently, a description of the research questions and hypotheses would follow the procedure. At the end of the research, an explanation of the limitations and significance of the findings is provided.

1.2 Research Background

'A Pure Tone Audiometry Study of Hearing Loss Using Air Conduction and Bone Conduction Assessment Among Young Adults in Johor' was designed for college students who had been using PLDs during the pandemic and would likely aim to investigate the prevalence and severity of hearing loss among this population. The study would involve administering PTA tests to a sample of college students who regularly use PLDs and analyzing the results to determine the extent of any hearing loss. The increased prevalence of remote learning and virtual classrooms has necessitated the use of PLDs, such as headphones or earphones, by several college students. These gadgets enable students to engage in online lectures and converse with their classmates. Nevertheless, the extended and excessive use of these gadgets might heighten the susceptibility to hearing impairment, particularly among young individuals who may lack awareness of the possible hazards.

This research also seeks to uncover possible risk factors for hearing loss among college students, such as the type and loudness of PLDs used, the length and frequency of usage, and any underlying health issues or lifestyle variables that contribute to hearing loss (Hussain et al., 2018; Hutchinson Marron et al., 2015; Paping et al., 2022). The study's results have far-reaching ramifications for college students, instructors, and public health in general. Identifying the risks and prevalence of hearing loss among college students may drive focused preventative and intervention activities, such as educational campaigns and public health messages on safe listening practices. It also led to the development of recommendations and procedures to limit the risk of hearing loss among college students who depend on PLDs during the epidemic and beyond.

The study investigate the prevalence and risk factors of hearing loss among college students using PLDs during the pandemic, as well as their attitudes and behaviors toward hearing health and safe listening practices (Agustiawan, 2022; Bawankule et al., 2022; Fink, 2022; Tonelli & Warick, 2022; Wagatsuma et al., 2022). For example, research examines whether college students are aware of the hazards associated with excessive PLD usage and whether they can reduce them by wearing noise-canceling headphones or taking listening breaks. The research also looks at how the epidemic has affected college students' hearing health and usage of PLDs, as well as their general well-being and mental health. For example, prolonged social isolation and virtual learning may have led to increased PLD usage among college students, which may have harmed their hearing health and mental well-being.

Researchers discovered that pupils in middle and high school who used PLDs extensively fared poorly. This study aimed to assess teens' PLD usage habits, listening beliefs, and perceived change in hearing, as well as to examine how the variables related to the reported change in hearing (Lee & Jeong, 2021). A Pure Tone Audiometry Study of Hearing Loss Using Air Conduction and Bone Conduction Assessment Among Young Adults in Johor for college students using PLDs during the epidemic might give crucial insights into the prevalence, risk factors, and effects of hearing loss in this demographic. These findings might be used to develop targeted treatments and policies to minimize the incidence of hearing loss and encourage safe listening practices among college students in Johor and elsewhere.

The mechanism of human hearing is a complex process that allows us to perceive and comprehend sound waves in our environment. Several structures and

processes must collaborate to convert sound waves into electrical signals that the brain can interpret (Skoe & Tufts, 2018). The ear consists of several components, including the pinna, ear canal, eardrum, ossicles, cochlea, vestibular system, and brainstem. The pinna, also known as the auricle, is a visible part of the ear composed of cartilage and skin. It collects sound waves and directs them into the ear canal, a tube-like structure covered with hairs and wax glands. The eardrum, also known as the tympanic membrane, responds to sound waves by delivering vibrations to the ossicles in the middle ear, separating the middle ear from the outer ear. (Mader & Windelspecht, 2016). The eardrum and inner ear space are connected by the ossicles, which are three small bones that transmit vibrations from the eardrum to the cochlea, a fluid-filled structure in the inner ear. The vestibular system, located in the inner ear, detects motion and maintains balance. It transmits electrical impulses from the cochlea to the brain via the auditory nerve, which is processed by the brainstem (Ars & Dirckx, 2016).

Sound waves enter the ear canal and travel to the eardrum, vibrating in response to sound waves. These vibrations are sent to the middle ear bones, which transmit the vibrations to the cochlea, which moves and activates tiny hair cells. The mechanical energy of vibrations is converted into electrical impulses, which are then sent to the auditory nerve, which is processed and analyzed before being transferred to the auditory cortex in the brain's temporal lobe. The auditory cortex is responsible for signal interpretation, enabling humans to sense and comprehend sound (Arráez-Aybar et al., 2010; Duncan & Cox, 2020; Ketel et al., 2020; Layona et al., 2018). This method has high sensitivity and can detect a broad spectrum of sound intensities and frequencies. In addition, the hearing system in our bodies enables us to differentiate between various sounds and localize a sound's origin in space.

Understanding the ear's components can help us understand the brain's ability to hear, analyze, and interpret sound, as well as reveal factors contributing to hearing-related disorders and illnesses. Hearing loss can occur at any age and is caused by genes, age, exposure to loud noise, infections, medications, and other health issues (Temirbekov & Celikyurt, 2020). Conductive hearing loss is the most common form, affecting small bones in the middle ear and can be treated with medication or surgical techniques. Sensorineural hearing loss is caused by trauma to the inner ear, causing permanent damage that can result from aging, exposure to loud noises, or certain medical conditions. Mixed hearing loss is the third type of hearing impairment, involving both conductive and sensorineural types of hearing loss (Augusto et al., 2017).

Hearing disorders can lead to various challenges and conditions, affecting a person's ability to listen and understand sounds (Ismail et al., 2021; Wroblewska-seniuk et al., 2018; Yu et al., 2015). Conductive hearing loss is the most prevalent type, characterized by an improper passage of sound waves from the outer ear to the inner ear. Sensorineural hearing loss is caused by damage to hair cells in the cochlea or the auditory nerve, often caused by age, exposure to loud sounds, or medical issues. Tinnitus is a condition where a person perceives buzzing, ringing, or humming sounds in one or both ears that are not brought on by any external source, significantly diminishing a person's quality of life (Lauer et al., 2019). Meniere's disease, also known as Ménière's illness, affects the inner ear and can cause vertigo, hearing loss, and ringing in the ears (Laine et al., 2020; Pai & Lee, 2013). Prolonged exposure to loud noise can cause irreversible hearing loss (Couth et al., 2020).

Audiometers are medical instruments used to diagnose hearing problems, including sensorineural, conductive, and mixed hearing loss. They help monitor the progression of hearing loss over time and evaluate the efficacy of hearing aids and therapies. The extent of hearing impairment is also considered when describing hearing loss (Hamberis et al., 2020; Manganella et al., 2018; Pawlaczyk-Łuszczyńska et al., 2017; Peñaranda et al., 2020; Riga et al., 2018; Vohr, 2018; Zaw et al., 2020). Normal hearing is measured between -10 and 20 decibels (dB), while mild hearing loss is estimated between 21 and 40 dB. Moderate hearing loss is measured between 41 and 55 dB, moderately severe hearing loss is between 56 and 70 dB, severe hearing loss is between 71 and 90 dB, and profound hearing loss is measured between 91 and 120 dB (more than 80 dB).

Audiologists, hearing healthcare specialists, and other medical professionals use audiometers to create pure tone impulses at a range of frequencies and intensities. These impulses are sent to the patient using headphones or speakers, allowing the audiometer to accurately assess the patient's hearing. The audiologist may then determine the patient's hearing threshold, or softest sound, by progressively adjusting the tone's loudness and frequency to find the softest sound that the patient can hear (Kocian et al., 2018; Shojaeemend & Ayatollahi, 2018). The patient's hearing threshold readings are recorded on an audiogram, which illustrates their hearing skills over various frequency ranges.

PTA is a non-invasive, painless, and practical method used to assess hearing sensitivity to various frequencies or pitches. It is an efficient and painless method for evaluating a person's hearing to determine if they have hearing loss or related conditions

(Pawlaczyk-Łuszczyńska et al., 2017; Skoloudik et al., 2020). A patient listens to a sequence of tones at varying frequencies and intensities in each ear, using headphones or earbuds. A audiologist plays the tones, starting with low frequencies and moving up to higher ones. Audiograms are created to show the patient's hearing sensitivity at different frequencies. This non-invasive, painless method helps determine a patient's hearing loss and provides information on potential treatment options like hearing aids or cochlear implants. The audiogram graph can assess the type, degree, and configuration of a patient's hearing loss, aiding in diagnosis and providing information on potential treatment options.

According to Shabana et al., (2021), PTA is a method used to assess the type and severity of a patient's hearing loss using either air-conduction or bone-conduction testing approaches. Air conduction (AC) audiometry involves using headphones to transmit pure tones to each ear at different frequencies and intensities, evaluating the patient's hearing. The tones are processed by the external, middle, and internal auditory canals before being transmitted to the auditory nerve, which sends impulses to the brain through the auditory nerve.

Bone conduction (BC) audiometry bypasses the outside and middle ears and directly stimulates the inner ear by vibrating the bones of the skull. This contrasts with traditional audiometry, which uses the middle and outer ears. A bone oscillator is placed behind the patient's ear and set to oscillate at a specific frequency, sending the tones straight to the cochlea, an organ for hearing found inside the inner ear through the skull bone (Beer et al., 2021; MEDEL, 2020). The patient is asked to identify when they hear each tone by raising their hand or pushing a button.

The hearing test involves plotting the results of two tests, BC and AC, on an audiogram to determine the degree and type of hearing loss. The AC test and auditory nerve test help identify the cause of the client's hearing loss, while the BC test indicates if the loss is due to the inner ear. BC testing is often performed when there is suspicion of an outer or middle ear issue affecting sound transmission. It can distinguish between conductive hearing loss, which affects the external and/or middle ear, and sensorineural hearing loss, which affects the inner ear or auditory nerve. The most effective approach to PTA is one that considers the unique needs of the patient and the test's objectives.

Young adult, a developmental period from late adolescence to the mid-twenties, is a universal stage of development that occurs in all cultures and locations. However, experiences and obstacles may differ based on gender, socioeconomic level, race, ethnicity, and cultural background. Young adults worldwide face challenges such as economic uncertainty, social and political turmoil, mental health concerns, and access to education and work opportunities. They also use technology and social media to interact and generate new personal and professional development opportunities. The Malaysian Youth Council defines young adults between 15 and 35 (Rosdina et al., 2010), while youth refer to individuals between 15 and 30. The transition into young adulthood is a complex and ever-changing stage of human development shaped by various personal, social, and cultural influences. Understanding the experiences of young adults worldwide is crucial to developing policies and programs that foster the well-being and success of this age group.

According to OMS, (2018) and Wu et al. (2020), The World Health Organization (WHO) predicts that by 2050, over 900 million people worldwide would

have hearing difficulties. Hearing loss, measured in both ears, can range from mild to severe, causing damage to one or both ears and making it difficult to hear noise or words. Hard hearing impairments are moderate to severe. Hearing-impaired individualrely on spoken language, hearing aids, and captioning services. Cochlear implants are necessary for those with substantial hearing loss. They communicate using sign language and other aids.

The National Institute of Occupational Safety and Health in Malaysia (NIOSH) has established occupational exposure limits for various physical and chemical agents. These restrictions are put in place to protect employees (Manivasagam, 2019). These restrictions have been imposed to shield the staff members from the possibly detrimental effects on their health that might result from prolonged exposure to a range of chemicals. During an eight-hour workday, an employee may only be subjected to a maximum noise level of 85 decibels (dB), as specified by the recommendations issued by the NIOSH of Malaysia. According to the provisions of the Occupational Safety and Health (Noise Exposure) Rules 2019, businesses must take measures to ensure that their staff members are not exposed to noise levels that are more than 85 decibels (dB) for eight hours. NIOSH suggests establishing a maximum exposure limit of 85 decibels for eight hours as the recommended value. The human auditory system would deteriorate without any intervention, which would be problematic in and of itself. Hearing loss might occur if a consistent noise exceeds seventy decibels.

Sounds with a decibel level higher than 120 can cause permanent harm to your hearing if they are loud enough (Murphy & Franks, 2002; Jiang et al., 2016). NIOSH

provides a daily noise dose, expressed as a percentage, to help individuals understand and manage their exposure to noise. The equal-energy rule suggests that time spent in potentially dangerous situations is cut in half for every three dB increase in ambient noise levels. Noise levels are assessed using sound power, but NIOSH exposure limits are calculated using time-weighted average exposures. If a reading is at least 85 dB, NIOSH recommends reducing noise output, limiting exposure duration, and wearing hearing protection. Hearing loss can result from noise levels above 85 decibels, increasing the risk of damage with noise intensity and exposure time. Preventing noise exposure in the workplace requires safeguards such as earplugs or earmuffs, noise control measures, and noise exposure risk training.

1.3 Problem Statement

Hearing loss is a common issue caused by exposure to loud or high-pitched noises, as the inner ear's hair cells are vulnerable to damage. This can lead to hearing impairment or tinnitus, a ringing sensation in the ears. To prevent hearing loss, individuals should take breaks from noisy activities, wear noise-cancelling headphones or earplugs, reduce electronic device volume, and avoid prolonged exposure to loud noises (Fink, 2022). Regular hearing tests are also crucial for early detection. Personal listening devices (PLDs) like earphones and headphones can cause ambient noise, damaging the hearing. Young adults who spend over eight hours daily listening to music via PLDs can also experience hearing loss and other auditory issues.

Insufficient studies have been conducted on the long-term consequences of PLD use on the hearing health of young adult (Apoorva Bhushan, 2019). It is necessary to conduct more studies to investigate the impact of PLD duration and volume on hearing thresholds, the prevalence of tinnitus, and other hearing diseases (Brown et al., 2018; Wu et al., 2020). The purpose of this study is to provide insight into the lasting impact of PLD on the hearing of young adults. It also seeks to contribute to the development of focused awareness campaigns and policy initiatives that encourage responsible use of PLDs and improve hearing health among young adults.

The study on the impact of PLDs on the hearing health of young adults has been constrained by its narrow emphasis on short-term and cross-sectional impacts, therefore limiting our understanding of long-term consequences (Bombarde & Deoghare, 2018; Fligor & Cox, 2004; Gopal et al., 2019; Hussain et al., 2018; Ketel et al., 2020; Vogel et al., 2011). It intends to track the number of PLDs ingested, changes in hearing thresholds, the prevalence of tinnitus, auditory symptoms over an extended period, attitudes toward hearing health, comprehension of safe listening practices, and the influence of peers.

PLDs provide young adults with access to a wide range of audio material, but prolonged and high-volume use may harm their hearing. Understanding the complex relationship between PLD usage habits, content choices, psychosocial variables, and hearing health can help create effective therapies and encourage safe listening among this vulnerable group.

This research is to determine young adults' PLD use, duration, volume, contexts, how music utilization affects hearing thresholds and auditory well-being. This study seeks to address knowledge gaps on the enduring effects of PLD use. It detected young adults at risk of hearing loss due to PLD use behaviors or loud settings and provided evidence-based guidelines for appropriate PLD use, hearing health awareness, and focused interventions to protect young adults' auditory health.

1.4 Research Objectives

The following are the study's objectives:

1. To design a pure tone audiometry screening test among young adults in Johor.
2. To analyze the Air Conduction and Bone Conduction test between the control and experimental group.
3. To evaluate Noise-Induced Hearing Loss among young adults.

1.5 Research Hypothesis

H01: There is no significant difference between air conduction and bone conduction using pure tone audiometry in hearing loss level.

H02: There is no significant difference between personal listening device users' hearing loss levels among young adults.

This study uses PTA to assess hearing loss and investigates the relationship between AC and BC. AC is the classic method of evaluating hearing sensitivity, which includes sending pure tones through headphones or putting earphones into the participant's outer ear. The sound travels through the outer and middle ear, activating the cochlea and eliciting a response. A bone vibrator is implanted on the mastoid bone behind the participant's ear, bypassing the outer and middle ear. The vibrations excite the cochlea instantaneously, prompting it to react.

According to the theory, the two conduction modalities might significantly differ in hearing loss levels. If the research findings back up the idea, it might mean that BC could be utilized better to detect the type or location of hearing loss. If BC thresholds are much more significant than AC thresholds, the hearing loss may be conductive (related to the outer or middle ear). If AC thresholds are much more significant than BC thresholds, this may indicate sensorineural hearing loss (inner ear or auditory nerve).

The second hypothesis proposes no significant difference in hearing loss levels among young adults who use personal hearing aids. Personal Hearing Device Users are teenagers who use PLDs such as headphones, earphones, or earbuds to listen to audio from various sources such as cellphones, tablets, laptop computers, and music players. According to the hypothesis, there is no statistically significant difference in the degree of hearing loss between these two groups of young individuals. If the research findings support this theory, PLD usage did not affect hearing loss levels in this group of young individuals. However, careful evaluation of the outcomes is crucial. While the hypothesis focuses on the association between PLD usage and hearing loss, it does not

rule out the potential that other variables, such as exposure to loud noise sources, genetic susceptibility, or other lifestyle choices, may contribute to hearing loss in the group investigated.

By evaluating these hypotheses, the research hopes to understand the relationship between different types of hearing loss and the potential influence of PLD usage on hearing health in young adults. The results may aid in our understanding of the risk factors for hearing loss in this age group, and they may have implications for public health policies, hearing conservation initiatives and education campaigns supporting safe PLD usage and hearing protection.

1.6 Significance of Study

The study on PTA in young adults has significant public health implications, detecting dangerous listening behaviors and raising awareness about unsafe PLD use. This could lead to interventions and educational campaigns for young adults, educational institutions, and parents (Agustiawan, 2022; Brown et al., 2018; Hussain et al., 2018; Lee & Jeong, 2021; Paping et al., 2022; Peñaranda et al., 2020). The study's findings can guide policymakers in creating evidence-based health policies for PLD use, including maximum volume levels laws and audio content provider criteria. Technology makers can also use the findings to provide safety measures for PLDs, promoting responsible use and safeguarding young adults' hearing health (Hutchinson Marron et al., 2015; Paping et al., 2022).

The study's findings help healthcare practitioners better understand the effect of PLD use on young adult's hearing health and provide targeted advice and counseling on safe listening practices. Preventive strategies for young individuals at increased risk of hearing impairment owing to PLD use may be created, with susceptible subgroups identified for targeted treatments. Longitudinal research on PLD use and hearing health may provide insight into the long-term consequences of excessive or dangerous listening behaviors, allowing healthcare systems to prepare for future hearing healthcare requirements.

The research on PLD use in young adults has considerable theoretical value, as it provides a screening test procedure for recognizing and preventing hearing loss in young adults in Johor. It can contribute to auditory science by investigating the association between PLD consumption and hearing health outcomes in each group, offering researchers and policymakers stronger information (Couth et al., 2020; Gordon et al., 2017; Manning et al., 2016; Zhao et al., 2010). The study on PTA has practical complications and application relevance, helping audiologists and healthcare professionals refine diagnostic and treatment approaches for patients with hearing loss, early detection, and intervention, hearing screening programs, public health strategies, occupational safety and standards, audiology training and education, hearing health awareness, hearing conservation programs, research and innovation, evidence-based policies, and audiometric testing guidelines.

1.7 Limitations of the Study

This research focuses on the use of Personal Hearing Aids (PLDs) among young adults aged 15 to 35 in Johor, Malaysia. The study aims to understand the differences in listening habits between college students and older individuals using PLDs. The participants were either male or female, and the research had limitations such as sampling bias, self-reported data, cross-sectional design, retrospective data, under- or over-reporting of PLD usage, difficulty in controlling variables, limited audiological data, causal vs. association, loss to follow-up, technological advancements, generalizability to future technologies, and the impact of noise exposure on hearing health.

The interpretation of the findings may not be accurate due to the participants' specific contexts or self-selection based on their interest in the subject matter. The heterogeneous nature of PLD use may also make it more challenging to interpret the findings, as various forms of material and listening situations might each uniquely impact a person's ability to retain their hearing. It is difficult to disentangle the precise impact of PLD use on hearing health since other factors, such as confounders and multifactorial influences, may also affect the hearing health of young adults.

Inconsistent definitions and metrics may raise ethical concerns, especially in longitudinal studies if participants are subjected to unsafe listening practices or possible damage due to the use of PLDs throughout the investigation. Access to audiological evaluation may not always be possible due to logistics or finances restrictions. The impact of noise exposure in everyday living, as well as cultural and socioeconomic

variables, may affect PLD use, and the results associated with hearing health (Autenrieth et al., 2012; Jennings & Shawb, 2008).

To overcome these limitations, researchers need to use reliable study designs, use verified measurement devices, and consider the complex nature of PLD use and its effects on young adults' hearing health. Future research may expand upon current information to provide successful interventions and public health strategies for encouraging the responsible use of PLDs and protecting young adults' hearing health (Goossens et al., 2017; Mamo et al., 2016; Wallhagen et al., 2019).

New listening behaviors and habits may emerge due to emerging technologies and the fast-changing landscape of audio technology and PLDs. These factors were not considered in the design of the research. However, researchers can increase the validity and dependability of their results by adopting robust study designs, collecting objective audiometric data, and implementing thorough statistical analysis. A future study has the potential to provide valuable insights into the promotion of safe PLD usage and the protection of the hearing health of young adults if it considers these limitations and builds upon the findings of prior research.

1.8 Operational definition

1.8.1 Hearing Loss / Hearing-impaired

Hearing loss is the difference between a person who cannot hear and someone whose hearing is normal, defined as hearing levels of 25 dB or more in both ears. Normal hearing is described as the ability to listen. There is a range that extends from mild hearing loss to moderate hearing loss to severe hearing loss to profound hearing loss. One or both ears can be impaired; when this happens, a person cannot hear speech, regardless of how loud it is (Rusinek, 2021).

1.8.2 Hearing threshold

A person's hearing threshold is the decibel level beyond which the individual's ears cannot detect any audible sound. The decibel level should ideally be 0 for adults, which is their default expectation. The rise in the hearing threshold that occurs directly from a threshold shift only applies to a particular sound frequency (Swierniak et al., 2020).

1.8.3 NIOSH REL

The National Institute for Occupational Safety and Health (NIOSH) has determined that the Recommended Exposure Limit (REL) for occupational noise exposure is 85 decibels, A-weighted, as an eight-hour average time-weighted average (85 dBA as an eight-hour TWA), with a conversion factor of three decibels. According to research

published by the Centers for Disease Control and Prevention in 2018, it is dangerous to go in either the right or the left direction (Murphy & Franks, 2002).

1.8.4 Noise Exposure

If someone is exposed to loud noise for an extended time, they may suffer irreversible hearing loss. This hearing loss is not correctable by medical procedures or the use of assistive listening devices. A transient sensitivity to loud noises may induce a sudden change in hearing (your ears may feel as if they are blocked up) or ringing in the ears (tinnitus) (Moore et al., 2017; You & Kwak, 2020).

1.8.5 Conductive Hearing Loss

Conductive hearing loss (malleus, incus, and staples) is caused by the ear canal, the eardrum, the middle ear, and the tiny bones in the ear (Coemert et al., 2020; Danesh et al., 2018; Lauer et al., 2019).

1.8.6 Sensorineural Hearing Loss

Sensorineural hearing loss (SNHL), also known as nerve-related hearing loss, is a condition that results from problems inside the inner ear (Laine et al., 2020; Pai & Lee, 2013; M. C. Wang et al., 2005; Wroblewska-seniuk et al., 2018).

1.8.7 Mixed Hearing Loss

Conductive damage to the outer or middle ear and sensorineural injury to the inner ear (cochlea) or auditory nerve may result in mixed hearing loss (Chordekar et al., 2018).

1.8.8 Noise-Induced Hearing Loss (NIHL)

Noise-Induced Hearing Loss (NIHL) is a hearing impairment caused by excessive noise exposure, causing damage to the inner ear or auditory nerve pathways (Gilliver et al., 2017; Paping et al., 2022; Swierniak et al., 2020; Vogel et al., 2011). This can lead to irreversible hearing loss. NIHL is often caused by loud locations and activities, such as concerts, heavy equipment uses, and occupational noise exposure in construction, manufacturing, or music sectors. The World Health Organization advises limiting exposure to noises exceeding 85 decibels to protect hearing health. To minimize NIHL, it is essential to wear hearing protection, maintain reasonable listening levels, take pauses, and avoid prolonged exposure to loud noises. Regular hearing tests can help detect hearing loss early, enabling prompt intervention and assistance.

1.8.9 Pure Tone Audiometry

The preliminary hearing test was used to categorize an individual's hearing thresholds, which enabled the degree, types, and configuration of hearing impairment to be determined. This paved the way for the diagnosis and therapy that would follow (Paping et al., 2022).

1.8.10 Air Conduction

In the natural world, hearing is accomplished by transmitting sound waves through the atmosphere. Sound is transmitted via the outer, middle, and inner ear through AC. Because of this, air conduction audiometry is a reliable technology that may be used regularly to evaluate a person's hearing capabilities (Beer et al., 2021; MEDEL, 2020).

1.8.11 Bone Conduction

An oscillator is implanted in the patient's bone as part of the BC audiometry test, which causes vibrations to be sent to the inner ear. The thresholds for BC in a given ear are expected to be comparable to or greater than those for AC in that ear (Dauman, 2013; Ismail et al., 2021; Kocian et al., 2018).

1.9 Summary

The increased prevalence of PLDs among college students because of the pandemic has increased their vulnerability to hearing impairment. The objective of this study is to examine the frequency and intensity of hearing loss within this demographic utilizing PLDs in Johor. Analyzing the results of PTA tests administered to a sample of students to ascertain the extent of hearing loss would constitute the research.

Hearing impairments may lead to conductive, sensorineural, or mixed hearing loss; among these, conductive hearing loss is the most common and can be managed by

medication or surgical interventions. Hearing loss individuals frequently depend on captioning services, hearing aids, and spoken language as means of communication. By 2050, the World Health Organization projects that more than 900 million individuals would suffer from hearing loss. Hearing protection strategies include avoiding protracted exposure to harsh disturbances or high-pitched sounds, taking breaks from noisy activities, and applying noise-canceling headphones or earplugs.

Hearing loss can cause difficulty in hearing conversations, muffled sounds, ringing in the ears, and difficulty understanding background noise. To address hearing loss, it is essential to seek help from a trained specialist and regularly test for hearing problems. Treatment options include hearing aids and cochlear implants, as well as assistive technology and lifestyle adjustments. Protect the hearing and seek help if noticed any changes in hearing clarity. Additionally, reduce the volume of electronic devices. A study assessing hearing loss in young adults via PTA examines the relationship between BC and AC.

Automated audiometers are crucial for interference detection, as persistent hearing conditions can negatively impact various aspects of a person's life, including learning and feelings. An audiogram is a graph that illustrates a person's hearing capacity and the number of hearing loss concerns on both sides of the auditory canal. The "hearing threshold" represents the slower tone of each frequency, and the audiogram compares the individual's hearing to normal hearing. Hearing loss can present in various forms and degrees, with specialists distinguishing between severe and substantial forms based on the ear affected.