An Investigation of the Effects of Noise Exposure and History of Otitis Media on Hearing Thresholds in a Student Population

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To DeafHear.ie, thank you for creating a masterpiece of a mannequin and allowing Kelly and myself to visit and speak with you.

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ABSTRACT

**Background:** People’s devotion to music and the proliferation of personal listening devices (PLDs) has become a cultural phenomenon, yielding concerns from researchers and media that noise-induced hearing loss (NIHL) is increasing substantially in the 21st century. Research has indicated that young adults, more than ever, are engaging in risky listening behaviors. There is a lack of audiological evidence in regards to NIHL and studies do not include history of otitis media (OM) in their research.

**Purpose:** To identify whether there is a correlation between NIHL and preferred listening levels on PLDs, to determine the percentage of those engaged in risky listening habits, and to identify if a positive history of OM is linked to increased hearing thresholds in young adults.

**Method:** 52 participants, aged 21-34 years, completed a questionnaire specifying medical history and hearing habits. Audiological assessments including pure tone audiometry and gap detection were incorporated. Participants PLD listening levels were measured.

**Results:** 4-8% of participants were found to engage in potentially risky listening behavior using PLDs for 4-6 hours per day at 60% volume. 6% of participants presented with moderate NIHL, while 23% fell above the 25dB threshold, indicating mild NIHL. There was no significant relationship found between listening habits or history of OM and NIHL/hearing thresholds.

**Conclusion:** According to the findings in this study; the majority of users in this population are not at risk for NIHL and only a few engage in risky listening behaviors. Additionally, no significant relationship was found between OM in childhood and hearing levels in adulthood.
Introduction & Background

Noise exposure has long been known to be a risk factor for hearing loss (Dalton et al. 2001). NIHL may be caused by a single exposure to an intense sound such as an explosion, or more commonly, by prolonged exposure to noise levels over 85 decibels (dB) (Rabinowitz 2000). Exposure to loud noise results in damage to the structure of hair cells in the inner ear, resulting in a sensorineural hearing loss characterized by the presence of a notch between 3 and 6kHz on the individual’s audiogram (ASHA 2011), as shown in Figure 1. As well, NIHL can cause sounds to become distorted while also causing tinnitus, a ringing or buzzing in the ear or head in the absence of an external stimulus (Daniel 2007) with symptoms lasting up to a year or more (Levey et al. 2011).

Minor decreases in hearing are common after 20 years of age, with some 20% of people over 50 years of age and almost 45% of people over 70 affected by presbycusis (age-related hearing loss) of a significant degree (DeafHear.ie 2009).

While NIHL begins as a notch in the 3-6kHz range, the notch broadens with increased exposure, and may eventually become indistinguishable from the otologic changes of aging (presbycusis), where an individual’s hearing shows a gradual deterioration, most markedly in the high frequencies (McBride and Williams 2001; Rabinowitz 2000). Consequently, differential diagnosis of NIHL is easiest in the under 50 age-group.

In addition to defining NIHL as a type of hearing loss, NIHL is also classified based on the degree or severity of the audiometric notch (ASHA 2011). Figure 2 illustrates a commonly used classification system of hearing loss. In the past decade alone, exposure to recreational noise has increased, with 12-50% of young adults acquiring hearing deficits attributable to noise exposure such as listening to personal listening devices (PLDs) (Niskar et al. 2001; Peng et al. 2007; West and Evans 1990; Cheesman and Steinberg 2010).
Figure 1: Audiogram of a 30dB bilateral notch indicating mild NIHL

Figure 2: degrees of hearing loss expressed in decibels (dB).

<table>
<thead>
<tr>
<th>Normal</th>
<th>-10 to 25</th>
<th>Moderately Severe</th>
<th>56-70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>26-40</td>
<td>Severe</td>
<td>71 to 90</td>
</tr>
<tr>
<td>Moderate</td>
<td>41-55</td>
<td>Profound</td>
<td>91+</td>
</tr>
</tbody>
</table>

Source: ASHA 2011

Listening to music is the second most popular media activity with ownership of PLDs increasing from 18% to 76% in the past 5 years alone (Rideout et al 2010). PLDs have evolved over the years due to enhanced memory capabilities and the portability of modern PLDs (including MP3 players, iPods, iPhones and other cellular devices) which allow individuals to listen for longer periods of time (Rabinowitz 2000; Punch et al 2011; Levey et al 2011; Danhauer et al 2012). The proliferation of PLDs has raised concerns as a tremendous quantity of audio stimulation can now be regularly introduced to the user’s ears (Berger et al 2009; ASHA 2011). Fligor and Cox (2004) recorded peak output levels of commercially available devices to be as high as 123dB. The exposure time (how often and for how long) and the listening levels are the main factors that influence hearing damage (Hammershøi et al 2006 cited in Camarero and Dominguez 2007). Previous studies indicate that although most PLD users select levels within a safe listening range, there is a small subgroup of the population, the majority of whom are students, who report listening to PLDs at a potentially hazardous level (Niskar et al 1998; Niskar et al 2001). With audiometric evidence of NIHL found in 12.5% of 6-19 year-olds, (Niskar et al 2001), there is
growing concern that NIHL will occur at an accelerated rate in this tech-savvy generation of young people (Levey et al 2011).

Temporary childhood hearing impairment due to otitis media (commonly known as ‘glue ear’) is widespread, with more than 80% of children developing OM before age 3, and 40% having six or more recurrences by 7 years of age (Vergison 2010). Children with recurrent episodes of ear infection have a higher risk of developing conductive hearing loss during childhood (Shriberg et al 2000). It is not known whether a positive history of OM is a contributory factor in the development of hearing loss in later life.

The purpose of this review, based on previous literature, is to acknowledge modifiable and un-modifiable risk factors in NIHL, to determine if there is a specific listening level that is a risk to NIHL, and if there is a correlation between OM and increased hearing thresholds in young adults.

Methods of Previous Research

Several studies chose surveys, mannequins, or gap detection tests as stand-alone measures; therefore limiting themselves to data that does not accurately reflect the relationship between PLD listening levels and increased hearing threshold levels (e.g., Punch et al 2011; Chung et al 2005; NIOSH 1998).

Previous studies in the field of NIHL have largely consisted of surveys as they allow large-scale sampling of risky NIHL behaviors (Chung et al 2005; Levey et al 2011). While this method allows researcher’s access to a diverse population, there lies a discrepancy between reported and actual listening levels (Portnuff et al 2011; Danhauer et al 2009).

Additionally, studies consisted of equipment such as mannequins and acoustic ears (e.g., Williams 2005; Hodgetts 2007; Portnuff and Fligor 2006) to measure participants’ listening levels. Between 14-25% of teens reportedly engage in risky listening behavior using mannequin studies (Williams 2005; Portnuff et al 2011); however mannequins do not have the same physiological features as human ears therefore discrepancies exist in the data.

Lastly, gap detection has been used to measure NIHL (Au 1992 Humes et al 2009). Gap detection thresholds are an important test of the temporal resolution of the human auditory system (Samelli and Schochat 2008). A person’s ability to hear gaps in tones and noises measures the individual’s ability to resolve differences in time. Temporal integration is the rate at which the auditory system responds to changes in intensity (Samelli and Schochat 2008). Therefore if young
adults are listening to PLDs at higher volumes and increasing their risk of NIHL, they also increase their risk of distinguishing gaps in high frequency sounds. Humes et al (2009) found that a normal individual can detect a 1-2 millisecond gap if the stimuli are presented at a comfortable volume level. 7-12% of adults showed a hearing deficit induced by noise exposure using gap detection tests.

This study will focus on a combination of questionnaires, audiograms, mannequins, and gap detection to determine if differences exist between self-reported and laboratory measures.

NIHL from long-term, high levels of sound exposure usually develops insidiously with significant hearing loss existing before the individual becomes aware of his or her difficulty (Levey et al 2011). Several factors must be considered to develop a complete profile of a NIHL.

Un-modifiable Factors

Un-modifiable risk factors for NIHL include environment, gender, and age. An individual’s acoustic environment is an involuntary contact with noise, which may affect the listening level that a person sets on his PLD (Fligor 2009; Worthington et al 2009). Past studies report up to 60% of participants’ use their iPods during physical activities or commuting (Chung et al 2005; Williams 2005). As background noise levels are higher in these settings, participants’ consequently select higher volume settings on their PLDs than would otherwise be the case (Danhauer et al 2009; Wilson and Herbstein 2003 cited in Goodman 2009). In many cases, the presence of outside noise alone can be a risk factor for NIHL; as shown in a 2006 study, which found ambient noise levels of up to 112dB in New York City subways (Gershon et al 2006). Exposure to high levels of ambient noise can be compounded by the selection of higher listening levels, resulting in a ‘chicken and egg’ scenario, whereby differential diagnosis of NIHL due to one noise source versus another is problematic. In addition to measurement of preferred listening levels, this study will consider background noise when determining risk levels of NIHL.

Gender is a significant contributory factor in NIHL. A U.S. study of NIHL in over 4,000 adolescents, surveyed in 1988-2004 and in 2005-2006, found a similar prevalence of exposure to recreational noise, a lower prevalence of hearing-protection use compared with male participants, and an increase in noise induced threshold shifts (NITS) prevalence among female participants between survey periods (Henderson et al 2010). Recent studies have shown that females have a lower risk of NIHL from PLD use, choosing volume settings in the 25-50% range, compared to men who chose volume settings within the 60-85% range (Kahari et al 2011; Portnuff et al 2009; Ahmed
et al 2006). As well, females are more frequent club and concert attenders (Kahari et al 2011), exposing their ears to average sound levels ranging between 95-140dB (Ahmed et al 2006; Kahari et al 2011). Studies of hearing thresholds and PLD use, found that males hearing threshold levels were 40% higher than female participants (Fligor and Ives 2006; Torre 2008). Holmes et al (2007) suggest that listening levels may be related to sensory responses, as males may have higher sensation-seeking levels than females. This suggests that while females may select lower preferred listening levels on PLDs than their male counterparts, this may be counterbalanced by more frequent exposure to high levels of ambient noise in club and concert environments. Additionally the age profile of participants must be considered in any study of gender difference in NIHL.

Teenagers and young adults are the largest population of PLD users (Williams 2005; Ahmed et al 2006). Consequently, much of the research on NIHL targets populations between the ages of 6-19 years, with a heavy focus on hearing acuity and its consequences for the development of communication, behavioral, and social skills (Niskar et al 2001; Niskar et al 1998; Berger et al 2009). It was found that undergraduate students, compared to older adults, frequently listen to music at higher volume levels (Portnuff et al 2009; Levy 2006; Hoover and Krishnamurti 2010) with 40% of students aged 16 to 25 years having audiometric evidence of NIHL. This study will examine the hearing thresholds of the student population between the ages of 21-34 to determine if a relationship exists between an older student population and greater PLD use.

Modifiable Factors

Modifiable factors include music genre and earphone type (Berger et al 2009). Generally, headphones for personal use do not incorporate acoustic insulation to protect from external noises (Camarero and Dominguez 2007). Fligor and Ives (2006) found that preferred listening levels for different styles of earphones is not a factor, concluding that typical listeners could use their iPod earbuds safely at 70% of full volume for 4.6 hours a day. This contradicts Hodgetts et al (2007), and Fligor and Cox (2004), who found significant differences between mean output levels in participants’ ear canals when they wore iPod earbuds versus others in background noise levels of 80dB or higher. Fligor and Ives (2006) illustrated the relationship between earphone style and background noise, noting that in a quiet environment, approximately 6% of participants were deemed at risk. However, in a noisy environment, between 20% and 80% of participants were at risk, depending on the degree of earphone attenuation. As Danhauer et al (2009) asserts, given the interaction between these variables, potentially all earbud users may be at risk for NIHL.
Frequency content, and volume peak levels can vary according to music genre, thus, the type of music being listened to is a parameter which may affect the sound exposure (Camarero and Dominguez 2007). To establish whether someone is truly at risk, exposure levels should be based on daily exposure, considering any changes in music genre (Camarero and Dominguez 2007). Exposure to sound can be misunderstood and misleading if only applied to a specific event; therefore genre, while an important factor, should be approached with caution.

**How Loud is Too Loud?**

Current practices in the United States provide several different definitions of NIHL (AAA 2012; AMA 2008) and there are no agreed international standards for tracking NIHL (Dobie and Megerson 2000; Rabinowitz et al 2006). An audiometric notch is the best indicator for NIHL, as it has been observed that the majority of notches, which present at 4kHz, may be masked when viewing the pure tone average thresholds of 1–6kHz, which is typically used as a measure of hearing acuity (Cheesman and Steinberg 2010). NIHL is typically centered around 3,000, 4,000, or 6,000kHz with recovery at 8,000kHz, (ACOEM Noise and Hearing Conservation Committee 2003).

Additionally, individuals exposed to noise levels at 85dB or higher for a prolonged period of time (8 hours or more) are at a high risk for hearing loss (AAA 2012; NIOSH 1998). However, a 3db time intensity trading relationship is assumed, such that a noise level of 88dB (85 + 3) is allowable for 4 hours, 91dB is allowable for 2 hours, etc. (NIOSH 1998 cited in Punch et al 2011). Portnuff and Fligor (2006) found that for maximum volume settings, periods of up to only 18 min per day were safe. At higher volume settings, specific limits ranged from 3 minutes to 20 hours depending on earphone type with no differences in music genre.

Researchers have attempted to determine maximum safe PLD volume levels using both artificial mannequins with artificial ears, and human subjects with probe microphones inserted into their ears (Williams 2005; Levey et al 2011). Overall, the literature falls short in providing definitive information on risks of NIHL from PLD use. While studies carried out in laboratory settings provide a more robust manner of measurement (Worthington et al 2009; Fligor and Cox 2004), a mannequin’s ear does not have the same acoustic/physiological properties as a human ear. Research findings to date are equivocal with regard to risk of NIHL and PLD use, with Dalton et al (2001) and West and Evans (1990) finding no risk, while Levey et al (2011) study, which tested 189 students using PLDs, found that 52% of users exceeded recommended exposure limits increasing their risk for NIHL.
OM on Hearing Thresholds in Young Adults

There are no available studies that estimate the risk for adult hearing loss associated with recurrent episodes of OM in childhood. Holmes et al (2007) found that a slight, unnoticeable hearing loss acquired during childhood may be exacerbated by intense sound exposure and contribute to a substantial hearing loss in adulthood. However, this study did not specify if this was due to OM or to chronic sound exposure at a young age.

Several constraints may explain the lack of risk data on OM and hearing loss. Firstly, research designs used in OM studies usually include retrospective data on the frequency, type, and duration of episodes of OM, but not on hearing levels (Vergison et al 2010; Bonding and Lorenzen 2010). Designs that do include hearing data such those used by Shriberg et al (2000a), Shriberg et al (2000b), and Wallace and Hooper (1997), focus on the effects of chronic OM on language and speech development due to elevated hearing thresholds. While several authors have studied children between the ages of 2-4 years with follow-up studies at age 7 years (Wallace and Hooper 1997; Vergison et al 2010; Bonding and Lorenzen 2010) there is a paucity of long-term follow-up studies. Grommet usage is also poorly detailed in previous studies. Grommets, also known as ventilation tubes, are the standard surgical treatment for aeration and drainage of fluid in the middle ear resulting from recurrent episodes of OM (Kids Health 2013). This study aims to examine the association of OM, grommet use and hearing loss within a student population ages 21-34 years.

Conclusion

Currently, PLD use may be a risk factor for NIHL in young adults. Music, compared to other occupational and recreational noise, is seen as a better measure of testing NIHL as different types of music varies in frequency and peak levels. With young adults listening to music at higher levels for longer periods of time, research shows a tremendous amount of audio stimulation can be regularly introduced to ears (ASHA 2011). While it is vital to consider earphone type and PLD brand; environmental noise, personal listening styles, age, and gender all contribute to risk factors for NIHL.

Present Study

The present study aims to identify if a correlation between increased hearing thresholds and preferred listening levels on PLDs exists. With the lack of research available on OM in
reference to the adult population, this study aims to identify whether or not there is a correlation between occurrences of OM and hearing loss in young adults. The following hypotheses were tested:

**Hypothesis 1:** Participants will select sufficiently high listening levels that will place them at risk for NIHL.

**Hypothesis 2:** The increased preferred listening levels of this group will be reflected in their audiograms by a classic NIHL ‘notch’ in the range of 3-6kHz.

**Hypothesis 3:** There will be a statistically significant relationship between a history of OM and increased hearing thresholds.

**Methods & Materials**

**Participants**

52 people (36 females, 16 males) participated in this study on a voluntary basis. Participants were between the ages of 21-34 years with class standing not reported on survey form. Informed consent (Appendix 2) was obtained given the voluntary nature of completing this survey and the UL Education & Health Science Research Ethics Committee approved the protocol.

**Survey Instrument**

A 25-question survey was created by researchers at the Department of Clinical Therapies at The University of Limerick (Appendix 3). The survey was adapted from several PLD and hearing questionnaires (e.g., Danhauer et al 2009; Levey et al 2011; Williams 2005), targeting hearing habits and hearing health history. The survey collected demographic data such as age and gender. As used in previously published studies (e.g., Airo et al 1996; Williams 2005; Worthington et al 2009), self-reported listening duration was considered an appropriate variable for estimating weekly exposures. Although the use of self-report data introduces errors in measurement, there is evidence that supports self-report use of ear-level devices as closely matching actual behavior in specific contexts (Chan 2009). The survey format included multiple choice, yes/no, and open-ended questions designed for easy completion.

No identifying information was included in the survey as it was administered anonymously. Exclusionary criteria included: participants with a developmental history of hearing loss, any medical history of aural pathology, and any usage of ototoxic medications. The responses of each question were reported in percentages. Participants were instructed to complete the survey in
front of the authors and surveys were collected immediately after completion. Survey data was analyzed using SPSS-20.0 statistical software.

Audiologic Examination

Audiologic examination was performed by postgraduate students at the Department of Clinical Therapies at the University of Limerick. Pure-tone audiometry with Telephonics 396D000-7 earphones using a Kamplex KS 8 audiometer was performed on subjects at the following frequencies: 500, 2000, 3000, 4000, 6000, and 8000Hz. Pure-tone audiometry is the gold standard for measuring an individual’s hearing threshold levels, enabling determination of the presence, degree, type, and configuration of a hearing loss (Bess and Townsend 2003). All audiometric thresholds were measured and expressed in decibels (dB), according to diagnostic audiometry protocol (BSA 2011). Strict criteria for the degree of notch were used as a means of comparing differences between small and substantial audiometric notches (Niskar 2001). The following categorization was applied to the audiometric thresholds per ear:

0. No Notch: audiograms with hearing thresholds below 10dB between 3-6kHz in either ear.

1. Small Unilateral Notch: maximum threshold level of 3-6kHz at least 10dB poorer than the pure-tone average of thresholds at 0.5-2kHz and threshold level at 8kHz at least 5dB poorer than the maximum threshold level at 3-6kHz in either ear.

2. Small Bilateral Notch: maximum threshold level of 3-6kHz at least 10dB poorer than the pure-tone average of thresholds at 0.5-2kHz and threshold level at 8kHz at least 5dB poorer than the maximum threshold level at 3-6kHz in both ears.

3. Large Unilateral Notch: maximum threshold level of 3-6kHz between 15 and 20dB poorer than the pure-tone average of thresholds at 0.5-2kHz and at least 15dB poorer than the threshold level at 8kHz in either ear.

4. Large Bilateral Notch: maximum threshold level of 3-6kHz between 15 and 20dB poorer than the pure-tone average of thresholds at 0.5-2kHz and at least 15dB poorer than the threshold level at 8kHz in both ears.

5. Large/Small Notch: maximum threshold level of 3-6kHz between 15 and 20dB poorer than the pure-tone average of thresholds at 0.5-2kHz and at least 15dB poorer than the threshold level at 8kHz in either ear. Maximum threshold level of 3-6kHz at least 10dB poorer than the pure-tone average of thresholds at 0.5-2kHz and threshold level at 8kHz at least 5dB poorer than the maximum threshold level at 3-6kHz in either ear.
Finally, to identify significance of the degree of hearing loss, participants’ hearing was classified from normal to profound as illustrated previously in Figure 2. Ambient noise levels were recorded each day using sound levels meters before assessments began.

Other Instrumentation

**Devices and Songs.** Each participant was required to select their preferred listening levels on the following three devices: an Apple iPhone 4S, a Zen X-Fi 3 MP3 player, and a Dell Inspiron N5110PC (Appendix 4). Stock earphones were provided. Participants were asked to listen to a 3-song playlist loaded onto the above three devices in the genres of “pop/hip-hop”, “dance” and “singer/songwriter”. The following songs were used: ‘Gangham Style’ by PSY, a popular dance song for 2012, ‘The A Team’ by Ed Sheeran for singer/songwriter, and ‘Locked out of Heaven’ by Bruno Mars, for pop. All three songs were chosen for their steady modulation which would provide listeners with a consistent sound level thereby allowing for limited adjustments to volume levels. The order of the songs and devices used was randomized for each subject. The participant requested that the researcher either increase or decrease the volume and participants were not allowed to see the volume percentage as this could alter their ‘true listening levels’.

Following assessment, researchers contacted Limerick’s DeafHear Association who created a sound level mannequin (a bespoke model based on the Jolene mannequin created by Levey et al (2011)), to calibrate each of the chosen PLDs volume output levels. The mannequin displays 12 colored sensors, each indicating a different volume output level: green indicated volumes less than 82dB, orange between 82-84dB, and red 85dB and higher. As illustrated in Figure 3, when earphones were placed against the mannequin’s ears, the sensor lights illuminated indicating the output level.

Finally, a gap detection test was administered using Windows Media Player program on the Dell Inspiron N5110PC and Apple MacBook OS X 10.8.2, with devices being used interchangeably.
Figure 3: A sound level mannequin created by Deafhear.ie was used to determine PLD volume output levels.

(Photo taken by Kelly Schuster)

Statistical Design & Analyses.

All statistical analyses were performed using SPSS 20.0. Some detailed analyses were performed per ear (i.e. pure tone threshold right ear and pure tone threshold left ear). However, the majority of results were considered per participant. Data was collected based on the following variables: age, gender, earphone type, PLD type, participants’ chosen listening levels, family history, gap detection, hearing threshold levels, and audiometric notch.

Results

Descriptive statistics were used to look at relationships between increased hearing thresholds and volume levels of PLDs and between occurrences of OM and hearing loss in young adults. A P-value of < 0.05 was taken as the level of statistical significance.

Effects of Survey

Fifty two subjects satisfied the inclusionary criteria and thus were included in the study. Sixteen (32%) were male and 36 (68%) were female. The mean age was 25.8 (range 21-34 years), and 80% were students at the University of Limerick. All subjects used PLDs for at least 1 hour per day. 44% used their mobile phone along with PLDs as a form of musical entertainment. Headphone styles were similarly varied with the majority of subjects using “earbud” style headphones. Subjects were also questioned in regard to exposure to other sources of noise including clubs, concerts, and pubs. 42 (80%) responded positively having attended at least two of these events within the past month. Additionally, 8 participants’ reported having previously experienced tinnitus after attending concerts, clubs, or pubs.
Effects of Pure-tone Audiogram and Gap Detection

**Hypothesis 1:** Participants will select sufficiently high listening levels that will place them at risk for NIHL.

To investigate the correlation between listening levels and duration of use, a Pearson R nonparametric t-test was used. Participants’ average selected listening levels were 42.36% (SD=13.71) ranging from 20-76% of full volume measured across three devices and three songs. As shown in Table 1, most participants listened between 0-1 hour at 30-39% of full volume while 6% engaged in risky listening behaviour listening at 60% of full volume or higher. Based on the value, T (15)=15.061; p<.447 (2-sided) there was no significance between participants listening level and weekly listening durations.

Table 1

<table>
<thead>
<tr>
<th>% of full volume</th>
<th>20-29%</th>
<th>30-39%</th>
<th>40-49%</th>
<th>50-59%</th>
<th>60-69%</th>
<th>70-79%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours per week</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-1 hr</td>
<td>3</td>
<td>8</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2-4 hr</td>
<td>4</td>
<td>6</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>4-6 hr</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6+ hr</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The study queried whether male PLD users would choose higher listening levels than female users. There were a greater number of female participants compared to male participants in this study. Among male participants, only 8% listened at higher levels than females. An independent-samples t-test was conducted showing no significant difference in the scores for males and females and their listening levels: t (48)= .049, p= .962 (two-tailed) (Table 2).

Table 2

<table>
<thead>
<tr>
<th>Gender</th>
<th>Mean Value</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>42.50</td>
<td>13.472</td>
</tr>
<tr>
<td>Female</td>
<td>42.29</td>
<td>14.656</td>
</tr>
</tbody>
</table>

A Pearson R nonparametric correlation was used to examine the differences between age and participants chosen listening levels (measured in percentage of full volume). As shown in Table 3, no significance was identified r= -.025, p=0.863.
Table 3

<table>
<thead>
<tr>
<th>Chosen Listening Levels</th>
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</thead>
<tbody>
<tr>
<td>Age</td>
</tr>
<tr>
<td>Chosen Listening Levels</td>
</tr>
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</table>

In the present study, 50 participants were earbud users (94%), and only two participants used over-the-ear headphones (6%). With such a large amount of earbud users and nearly no over-the-ear noise reduction headphone users, we were not able to conduct statistical analyses to compare means. However, an independent sample Mann-Whitney U test was conducted in order to identify whether the distribution of notch was the same for subjects who use over-the-ear noise-reducing earphones. Results indicate no significant difference between variables (Md=4.00, n=8; p=.323).

Finally, results of PLD calibration using the bespoke mannequin revealed that iPhones produced levels of 85dB or higher at 50% of full volume, Zen produced levels of 85dB at 83% of full volume and Windows Media Player produced levels of 85dB at 36% of full volume.

**Hypothesis 2:** The increased chosen listening levels of this group will be reflected in their audiograms by a classic NIHL ‘notch’ in the range of 3-6000 Hz.

The study queried if hearing thresholds increased as age increased. Age was correlated with notch results using a Spearman’s Rank Order correlation test. The subjects’ tests showed that for the age group 22-26 years, there was a higher (worse) mean hearing threshold than any other age bracket (Table 4), however, there were no significant differences in the degree of notch with the increase of age (n= 51, r= -.204, p=.151).
Table 4

<table>
<thead>
<tr>
<th>Age bracket</th>
<th>18-21 years</th>
<th>22-26 years</th>
<th>27-31 years</th>
<th>32-35 years</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Notch categorization</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Notch</td>
<td>0</td>
<td>5</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Small unilateral</td>
<td>0</td>
<td>6</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Small bilateral</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Large unilateral</td>
<td>1</td>
<td>7</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Large bilateral</td>
<td>0</td>
<td>13</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Small/large</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Hearing threshold shifts were recorded for both ears over the standard frequency range 0.5–8 kHz. NIHL threshold shifts were calculated for high frequency bands (3, 4 and 6 kHz). In the present study, 80.8% of participants were identified as having a NIHL notch, as reflected by a 10db or 15dB dip in their audiograms. However, only 28.8% of participants fell above the 25dB threshold, indicating mild NIHL (N=12) or moderate NIHL (N=5) (Table 5). A one-way between groups analysis of variance (ANOVA) was performed to identify a difference between notch and participants’ chosen listening levels. Despite the ubiquity of notches among participants’ audiograms, chosen listening levels did not differ for notch type (F (5, 44) = .421; p = .832)(Table 6).

Table 5: Description of NIHL notch is discussed under ‘Introduction & Background’ p. 5
An independent samples Mann-Whitney U test was used to determine whether gender affects the presence or absence of a notch. A p-value of .920 proved there was no significant difference in the notches of males (Md=3.00, n=17) and females (Md=3.00, n=35). A Mann-Whitney U test was also used to determine if notch scores differed according to the type of earphones used. The p-value of .323 showed no significant difference. Lastly, PLD type and the presence or absence of a notch was compared. For all comparisons, no significant differences were found. Table 7 shows median and p-value results of the PLD types and the presence or absence of notch.

Table 7

<table>
<thead>
<tr>
<th>PLD Type</th>
<th>Mann-Whitney U Test value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significance of IPod/MP3 use &amp; the absence/presence of a notch</td>
<td>Md=3.00, n=29; p&lt;.955</td>
</tr>
<tr>
<td>Significance of PC/Laptop use &amp; the absence/presence of a notch</td>
<td>Md=3.00, n=48; p&lt;.718</td>
</tr>
<tr>
<td>Significance of Mobile Phone use &amp; the absence/presence of a notch</td>
<td>Md=3.00, n=41; p&lt;.738</td>
</tr>
</tbody>
</table>

In addition to examining participants’ audiograms for evidence of NIHL, a 5 frequency Pure Tone Average (PTA5) hearing threshold was calculated for each participant’s left and right ear. However, having conducted a Pearson correlation analysis, no significant relationship between hearing threshold and CLL was identified. Table 8 shows results of the hearing threshold by ear.
and chosen listening levels. Similarly, a one way ANOVA showed no significant relationship noted between hearing thresholds and age or notch. Table 9 shows the values. An independent t-test was used to determine the hearing threshold levels in both right and left ear and difference in gender. Table 10 and 11 show the values.

**Table 8**

<table>
<thead>
<tr>
<th></th>
<th>Values of participants average CLL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Hearing Threshold levels in right ear</td>
<td>( r = -.200, p = .163 )</td>
</tr>
<tr>
<td>Average hearing threshold levels in left ear</td>
<td>( r = -.105, p = .467 )</td>
</tr>
</tbody>
</table>

**Table 9**

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>Notch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Hearing Threshold in Right Ear</td>
<td>( r = -.060, p = .675 )</td>
<td>( F(5, 46) = 2.013; p = .095 )</td>
</tr>
<tr>
<td>Average Hearing Threshold in Left Ear</td>
<td>( r = .158, p = .264 )</td>
<td>( F(5, 46) = .862; p = .514 )</td>
</tr>
</tbody>
</table>

**Table 10**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Mean; SD</th>
<th>Hearing Threshold Values in Right Ear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>M=8.01, SD=4.68</td>
<td>T(50)=.408, p&lt;.701</td>
</tr>
<tr>
<td>Female</td>
<td>M=7.50, SD=4.06</td>
<td></td>
</tr>
</tbody>
</table>

**Table 11**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Mean; SD</th>
<th>Hearing Threshold Values in Left Ear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>M=8.45, SD=5.59</td>
<td>T(50)=-.613, p&lt;.590</td>
</tr>
<tr>
<td>Female</td>
<td>M=9.29, SD=4.01</td>
<td></td>
</tr>
</tbody>
</table>

A Pearson correlation t-test determined gap detection responses and the difference in hearing threshold levels in both right and left ear (Table 12). The test *approached significance* for the right ear and a *statistical significance* was found for the left ear.

**Table 12**

<table>
<thead>
<tr>
<th></th>
<th>Gap Detection Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Hearing Thresholds in Right Ear</td>
<td>( r=.254, p=.070 )</td>
</tr>
<tr>
<td>Average Hearing Thresholds in Left Ear</td>
<td>( r=.398, p=.004 )</td>
</tr>
</tbody>
</table>
A one way ANOVA was conducted to determine whether gap detection varied with age. Results indicate a *statistically significant difference* (F(3, 48) = 2.813; p = .049). However, it was not possible to run post hoc analyses to determine specific, between-group differences, as one group had less than two cases. Using an independent t-test, there was no statistically significant difference between gap detection responses in males (M=36.82, SD=6.858) and females (M=34.29, SD=7.748); t(50) = 1.148, p = .239. Lastly, a one way ANOVA, revealed no statistical significance between gap detection responses and notch (F(5, 46)=.387, p = .855).

**Hypothesis 3:** There will be a statistically significant relationship between a history of OM and increased hearing thresholds.

With the lack of statistical research on OM and hearing thresholds, this study aimed to find a relationship between hearing measures and the presence or absence of any history of ear infections, grommet usage and hearing loss. Participants provided information based on their own knowledge of their family history. Independent samples Mann-Whitney U test were used with results indicating family history as having no impact on hearing threshold or gap detection responses (Table 13).

<table>
<thead>
<tr>
<th></th>
<th>Family Hx of Ear Infection</th>
<th>Family Hx of Grommets</th>
<th>Family Hx of A Hearing Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notch</td>
<td>Md=3.00, n=29; p=.073</td>
<td>Md=4.00, n=7; p=.233</td>
<td>Md=4.00, n=21; p=.167</td>
</tr>
<tr>
<td>PTA 5 Right Ear</td>
<td>Md=7.50, n=29; p=.157</td>
<td>Md=7.50, n=7; p=.469</td>
<td>Md=6.25, n=21; p=.215</td>
</tr>
<tr>
<td>PTA5 Left Ear</td>
<td>Md=8.75, n=29; p=.797</td>
<td>Md=10.00, n=7; p=.937</td>
<td>Md=7.25, n=21; p=.548</td>
</tr>
<tr>
<td>Gap Detection</td>
<td>Md=34.00, n=29; p=.258</td>
<td>Md=32.00, n=7; p=.796</td>
<td>Md=32.00, n=21; p=.137</td>
</tr>
</tbody>
</table>

Participants also provided information on whether they have had ear infection in the past and how many they have had. Results from an independent Mann-Whitney U test confirmed that personal history of ear infection does not predict degree of notch for 0-1 ear infections (Md=3.00, n=25; p=.413), and 2-4 ear infections (Md=4.00, n=27; p = .413), nor does it affect PTA5-Left (p = .638), PTA5-Right (p = .224), or gap detection responses (p = 575). While there was no significance between personal history of ear infection and hearing thresholds (p=.517 for right ear, p=.268 for left ear), a large number of participants (N=11) who had between 2-4 ear infections during childhood presented with a large bilateral notch on their audiogram.
Discussion of Qualitative Results

One male participant presented with a clear acoustic trauma, a related condition that results from an acute export to short term impulsive noise. He believed he acquired this loss by standing close to amplifiers and this loss was asymmetrical, with an apparent damage to the right ear causing a moderate hearing loss. This male, compared to other participants, will presumably listen to his PLD at risky listening levels due to the hearing loss.

A larger percentage of participants reported iPod use compared to those surveyed in past research (Danhauer et al 2009; Williams 2005), supporting the claim that iPod use is prevalent in the college population. Since the Danhauer et al study was conducted in 2009 and the present study in 2013, this higher prevalence of iPod use may be related to the increasing availability and popularity of PLDs.

Despite the prevalence of surveys in studies (e.g., Williams 2005, Chung et al 2005), there is a belief that self-report measures may compromise a study’s validity, weakening the inferences drawn from the data (Chan 2009). Due to the lack of knowledge displayed by the participants on their duration of PLD use and medical history, self-report errors may have affected the accuracy of this data. Lastly, surveys may lead to biased, socially desirable responses (Chung et al 2005). However, in the absence of technical solutions to monitor participants’ durations of use, self-report is the most effective measure for surveying a large number of participants’ (Chan 2009).

Discussion of Quantitative Results

The increasing popularity of listening devices for young adults has led to professional and popular concern regarding the potential hearing hazards of PLDs. Maximum listening levels, while harmful (Fligor and Cox 2004), only apply to users who choose them. Additionally, as illustrated by PLD calibration; PLDs produce highly variable outputs at the same percentage of maximum output. With regard to Hypothesis 1, this study is consistent with previous research; identifying a small subgroup of the population who engage in risky listening behaviors (Punch et al 2011, Danhauer et al 2009).

According to Fligor and Cox (2004), use of PLDs should be restricted to a maximum of 60% of full volume for up to 60 minutes per day. This 60-60 rule was subsequently amended by Portnuff and Fligor (2006), who estimated that PLD users could listen at 70% of full volume for 4.6
hours per day. 8% of participants in this study exceeded the 60-60 rule, while 4% engaged in risky listening behavior based on the amended 70-40 rule.

NIHL risk is based on duration in addition to listening levels (Portnuff et al 2009; Levey et al 2011; Danhauer et al 2009). 40% of participants reported listening to PLDs for less than one hour per week and 4% of participants reported listening durations of longer than 6 hours per week. Overall, participants in this study were quite conservative with their listening habits. However, as information was provided on weekly, and not daily, use of PLDs; the study cannot conclusively state that participants were not exceeding the daily usage that would place them at risk for NIHL. A more detailed report based on daily exposure would have provided more knowledge on listening levels.

Many participants expressed their knowledge of how loud they listened to their PLDs in certain settings, such as the gym, and have heard about the media attention surrounding NIHL. With participants in this study having a clear knowledge of the “hazards” of PLD’s and what they can do to hearing, it is difficult to know if listening levels were accurate. It is conceivable that the overall PLDs may have been reported conservatively due to the participant’s unwillingness to inform the researchers of their true listening habits. Additionally, while listening levels in this study were measured in a quiet room, as highlighted by Worthington et al. (2009); many subjects use their PLDs during physical activities, consequently there will be a vast difference in true listening levels measured compared to those selected in noisy environments.

An approaching significance was detected for gap detection differences amongst age in Hypothesis 2. Age-related decline in threshold sensitivity has been well established in past studies (e.g., Snell 2000; Ross et al 2010). Findings detect that mean differences between age groups reflect shifts in the distributions of gap thresholds in older subjects. In other words, the older the individual, the poorer the individual’s temporal resolution, even though audiometric evidence proves ‘normal’ (Harris et al 2010; Ross et al 2010). Snell (2000) found significant age-related changes in auditory processing throughout adulthood when testing individuals. Ross et al’s (2010) study of subjects with normal hearing reported age-related differences in gap detection thresholds that were not correlated with audiometric thresholds but rather, age-related differences in selective attention. Past findings are consistent with our study as gap detection responses decreased as age increased (Snell 2000; Ross et al 2010). However, this too is subjective. It is well established that not everyone shares the same risk of hearing loss, given that some individuals
have “tougher” ears and others have “tender” ears (Levey et al. 2011). Therefore it is not possible to predict who is at a higher risk for NIHL.

A trend was noted in the correlations between gap detection responses and hearing thresholds in the left ear while a significant difference was found for the right ear. In some audiological procedures, the right ear was expected to perform better due to the left hemisphere advantage in performing auditory tasks of a temporal nature (Sulakhe et al. 2003). However, such patterns were not observed in this study, which is consistent with the results obtained by Baker et al. (2000) who reported asymmetry between the ears in gap detection responses.

Portnuff et al. (2009) and Levy et al. (2011) found that students, compared to older adults, engaged in risky listening levels; with 40% of students showing audиometric evidence of NIHL. Participants’ notches were not associated with PLD volume levels in the present study as participants’ noise exposures were insufficient to cause a notch. With regard to hypothesis 2; 6% of participants presented with moderate NIHL, 3% presented with a mild NIHL and 81% had audиometric evidence showing a normal ear defined by either a unilateral or bilateral notching below 25dB. Our study is consistent with Fligor and Ives’ (2006) study which illustrated the relationship between earphone style and background noise, noting that in a quiet environment, approximately 6% of participants were deemed to be at risk. In accordance with Ahmed et al. (2006) and Shah et al. (2009) studies, while results indicate that the average participant’s listening levels have no significance in hearing loss, some participants are still listening to PLDs at risky volume levels which could contribute to early NIHL. Perhaps participants in the present study who presented with a mild and moderate notch can attribute NIHL to other intrinsic and environmental factors that could cause hearing loss on their own or alter NIHL vulnerability (Levey et al. 2011).

80% (N=42) of participants reported attending at least two events in the past month. Loud music from concerts and clubs pose a potentially dangerous source of recreational noise. Sound levels at rock concerts have been recorded to reach 120-140dB, and the sound levels in clubs can reach 95dB on a weekend night (Chung et al. 2005).

Studies have suggested that men choose volume settings in the 60-85% range while females choose volume settings in the 25-50% range (Levey et al. 2011; Hodgetts 2007; Torre 2008). There is a disproportionate number of males (N=17) and females (N=35) in the present study compared to past research which found gender differences in PLD sound exposure or audиometric evidence (Fligor and Ives 2006; Portnuff et al. 2009; Torre 2008; Williams 2005). Additionally, previous research used different methods of measurement and environments across
investigations. Hodgetts et al (2007) and Torre’s (2008) study asked participants to adjust their listening levels in a laboratory setting whereas others tested listening levels against ambient noise (Fliogor and Ives 2006; Portnuff et al 2009). Perhaps a bigger sample would have given more insight into the difference between listening levels of men vs. women. Lastly, previous research was conducted in the United States. Societal differences could exist between Ireland and America that influenced the outcome for gender and their susceptibility to conform to cultural norms concerning listening behavior (Booth and Nolen 2009; Levey et al 2011).

In regards to Hypothesis 3, Al-Muhaimeed (1996) concluded that conductive hearing loss associated with secretory OM was shown in 66% of children cases that were tested. As well, Costa et al (2009) found that chronic OM in individuals 3-55 years was associated with sensorineural hearing loss. The present study found no relationship between personal or family history of ear infection, hearing loss, or grommet usage and the individual’s hearing threshold. However, 11 participants in the present study who had 2-4 ear infections as a child, presented with a large bilateral notch. It is important to note several participants had no knowledge of, or had forgotten if they had ear infections as children. Those who did have knowledge were not sure of how many they had in total. As with many infectious diseases, the nature of the burden of OM differs greatly between individuals (Vergison et al 2010); therefore, it is not possible to know whether differences in hearing health may have played any role in variations in listening levels. Additionally, because participants had no serious cases of OM and listening levels were not risky, audiometric evidence might not show substantial differences (Bess and Townsend 2003). Further studies are warranted to examine the relationship between OM in childhood and adult hearing thresholds.

Participants did not identify having frequent episodes of acute middle ear infection that would require grommet usage. 11% reported having 6 or more infections while 35% reported having between 1-4 ear infections as a child. Besides a lack of knowledge of medical history, grommets would not have been used by participants if they did not present with middle ear fluid for more than three months, or had six acute ear infections in one year (Browning et al 2010).

**Limitations**

This study had a small number of procedural and functional limitations which impacted the validity of the assessment. Limited information was gathered regarding medical history, therefore, as stated earlier, hearing health may have played a role in variations of listening levels.
The majority of PLDs are sold with the earbud style of headphones. Preferred listening levels are higher with this style of headphone compared to over-the-ear style (Hodgetts et al 2007). With only 6 participants’ reporting using over-the-ear, further research is warranted to compare types of headphones and listening output levels.

Testing for the pure tone audiometry and gap detection lasted 35 minutes. As a break was not given in between testing, fatigue could have hindered results of the tests. In ideal testing conditions, ambient noise levels should not exceed 35dB (BSA 2011). Testing was carried out in a clinic rather than a sound-treated room, with noise levels varying each day. During the 5 weeks of testing, a sound level meter indicated ambient noise ranging from 32dB to 42dB. Background noise can have a significant impact on the discrepancies of audiogram notches and participants’ actual hearing levels (Hodgetts et al 2007). Measures of listening volume levels were also completed in the clinic; therefore the participants true listening levels may be affected. Hodgetts et al (2007) tested three environments: quiet, street noise and multi-talk babble, and showed that on average, listeners had higher listening levels in street noise than in multi-talk babble and both of these were higher than the listening levels for quiet conditions.

**Conclusion**

NIHL is the second most common cause of adult hearing loss, after presbycusis (Rabinowitz et al 2006). According to these findings, users who were surveyed generally listened to their music at levels and for durations that resulted in exposures well below the OSHA guidelines for maximum noise exposure. However, there was a small group of participants who listened to PLDs at dangerous levels. Possibly with a larger sample population, there may have been a more audiometric evidence of NIHL.

Other intrinsic and environmental factors, along with PLD use, can contribute to early NIHL and could explain increased hearing thresholds exhibited in participants’ audiograms. However, the results do not indicate that the sampled population of listeners is at a substantially increased risk for hearing loss as a result of their listening habits.

There is a lack of research evidence to show what, if any effects OM has on hearing thresholds in young adults. A wider population with specific criteria’s regarding hearing health could give greater insight here.
Given the small sample size and a population consisting mainly of students, our estimates of population risk cannot be taken to be representative of the general population. Most importantly, the bias introduced by participating in an experiment and selecting a preferred listening level knowing that an objective measurement is forthcoming cannot be accounted for. Finally, additional risky exposure to other sources of noise is not accounted for in these computations, which consequently may underestimate participants’ true exposure.
REFERENCES


APPENDIX 1

Participant Information Sheet

Title of the study: An investigation of the effects of noise exposure and history of otitis media on hearing thresholds in a student population.

Introduction
We are students on the Masters in Speech & Language Therapy degree at the University of Limerick. This research aims to explore the effects of earphone usage and history of ear infection on hearing among students aged 18-35 years.

- Researchers who study hearing loss have found that a person who is exposed to noise levels at 85 decibels or higher for a prolonged period of time is at risk for hearing loss. Many devices that we use today have noise levels much higher than 85 decibels. For example, an MP3 player at maximum level is roughly 105 decibels - that's 100 times more intense than 85 decibels.
- Children with recurrent episodes of ear infection have higher risks of developing hearing loss during childhood. It is not known whether or not a history of ear infection in childhood can have long term effects on hearing.

What is the purpose of this investigation?
This research aims to explore the effects of both earphone usage and history of ear infection on hearing levels in the student population.

Why have you been invited to take part?
We would like to interview and test 35 male and 35 female students aged 18-35 years.

Do you have to take part?
Your participation is completely voluntary. If you decide to take part you will be given this information sheet to keep and you will be asked to sign a consent form. If you do decide to take part you are free withdraw from the research at any point without giving a reason and without fear of prejudice.

What will you do in the project?
If you decide to take part in this research, you will be asked questions about: your use of earphones; history of ear infection and/or hearing difficulties; family history of hearing loss; and environmental exposure to high levels of noise. Your hearing will then be tested using 3 different types of test: you will be asked to respond to noises hear through headphones; and to tell the difference between sets of different sounds. The total time taken for questions and hearing testing will be approximately one hour. Testing will take place in the Health Sciences Building in the University of Limerick.

What are the potential risks to you in taking part?
All information that is collected about you during the course of the research will be kept strictly confidential and anonymous. Only members of the research team will have access to it. Your name or any other contact details will not be recorded on any transcripts or test forms.

All data collection, storage and processing will comply with the principles of the Data Protection Act 1998 and the EU Directive 95/46 on Data Protection. In accordance with University policy, data generated from
the research must be kept securely in paper form for a period of seven years after the completion of the project, after which it will be destroyed. Under no circumstances will identifiable responses be made available to any third party. Information from the research will only be made public in a completely anonymised format or at an aggregate level in order to ensure that no participant can be identified. The hearing assessments used are completely safe and risk free.

**What happens to the information in the project?**
The results of this research will be used in our Final Year Project and will be published on the Department of Clinical Therapies website. Anonymity and confidentiality are ensured at all times. Additionally, this research may be presented at academic and professional conferences and in academic journals.

Thank you for reading this information – please ask any questions if you are unsure about what is written here.

**What happens next?**
If you decide that you would like to take part in this research, you can contact us by email at the addresses below. We will explain what the research is about, what is involved in the interview and testing process, and answer any questions you may have. You can then decide if you want to go ahead and we can arrange a suitable time and location. The location will be in a private room in the Health Sciences Building.

We will also ask you to sign a consent form to confirm that you wish to take part in the research.

If you do not wish to take part in this research, we would like to thank you for your time and attention.

**Researcher Contact Details:**
Kelly Schuster: ULStudent:KELLY.SCHUSTER [11146982@studentmail.ul.ie]
Shevon Walker: ULStudent:SHEVON.WALKER [11002352@studentmail.ul.ie]

**Chief Investigator Details:**
Tara Kearns, Department of Clinical Therapies, Health Sciences Building, University of Limerick.

email:tara.kearns@ul.ie. Tel: 061-234604.

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*This research has received ethical approval from the University of Limerick Research Ethics Committee. If you have concerns regarding this study, please contact: Chairman, Education and Health Sciences, Research Ethics Committee, EHS Faculty Office, University of Limerick, Tel (061) 234101 Email: ehsresearchethics@ul.ie*
APPENDIX 2

Consent Form

Title of the study: An investigation of the effects of noise exposure and history of otitis media on hearing thresholds in a student population.

- I confirm that I have read and understood the information sheet for the above project and the researcher has answered any queries to my satisfaction.
- I understand that my participation is voluntary and that I am free to withdraw from the project at any time, without having to give a reason and without any consequences.
- I understand that I can withdraw my data from the study at any time.
- I understand that any information recorded in the investigation will remain confidential and no information that identifies me will be made publicly available.

<table>
<thead>
<tr>
<th>Name of Participant</th>
<th>Signature</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Name of Researcher</th>
<th>Signature</th>
<th>Date</th>
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</table>

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### APPENDIX 3

**Case History Questionnaire**

| Participant No. | __________________ |
| Age | __________________ |
| Gender | Male/Female |

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you been exposed to loud music/noise in the past 24 hours? Please circle: Yes / No</td>
<td></td>
</tr>
<tr>
<td>If yes, please give details</td>
<td></td>
</tr>
<tr>
<td>____________________________________________________________________</td>
<td></td>
</tr>
<tr>
<td>Have you ever had an ear infection, either recently, or as a child? Please circle: Yes / No</td>
<td></td>
</tr>
<tr>
<td>If yes, approximately how many</td>
<td></td>
</tr>
<tr>
<td>And, when?</td>
<td></td>
</tr>
<tr>
<td>____________________________________________________________________</td>
<td></td>
</tr>
<tr>
<td>Is there a family history of ear infections? Please circle: Yes / No</td>
<td></td>
</tr>
<tr>
<td>If yes, please give details</td>
<td></td>
</tr>
<tr>
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<tr>
<td>Is there a family history of grommet usage? Please circle: Yes / No</td>
<td></td>
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<tr>
<td>If yes, please give details</td>
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<tr>
<td>Have you ever experienced a hearing loss? Please circle: Yes / No</td>
<td></td>
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<tr>
<td>If yes, please give details</td>
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<tr>
<td>Is there a family history of hearing loss? Please circle: Yes / No</td>
<td></td>
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<tr>
<td>If yes, please give details</td>
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<td>____________________________________________________________________</td>
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</tbody>
</table>
Please circle all/any answers that apply.

Which of the following do you use?

IPod/MP3 Player  PC/Laptop  Mobile Phone  None

What kind of headphones do you use?

Earbuds  Over the ear  Over the ear noise reduction  None

In which environments do you use your headphones?

Quiet area  Public Transport  Workout Sessions  In a vehicle

How many hours per week do you listen to music with headphones?

0-1 hour  2-4 hours  4-6 hours

6 or more hours (if more; please specify)  _________________

Please give a number for each of the following:

How many concerts/gigs have you attended in the past month?  _________________

How many clubs/parties have you been to in the past month? _______________
APPENDIX 4

Participant Preferred Listening Levels Form

Device #1: Apple iPhone

Song 1 – ‘The A Team’

-----------------------------------------------

Song 2 – ‘Gangnam Style’

-----------------------------------------------

Song 3 – ‘Locked out of Heaven’

-----------------------------------------------

Device #2: Zen X-Fi 3

Song 1 – ‘The A Team’

/31

Song 2 – ‘Gangnam Style’

/31

Song 3 – ‘Locked out of Heaven’

/31

Device #3: Dell PC

Song 1 – ‘The A Team’

/100

Song 2 – ‘Gangnam Style’

/100

Song 3 – ‘Locked out of Heaven’

/100

This research has received ethical approval from the University of Limerick Research Ethics Committee. If you have concerns regarding this study, please contact: Chairman, Education and Health Sciences, Research Ethics Committee, EHS Faculty Office, University of Limerick, Tel (061) 234101 Email: ehsresearchethics@ul.ie