Instrumental Music Teachers: Music Exposure and Hearing Loss

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ABSTRACT

Most music teachers experience lengthy periods of noise exposure on a daily basis, which, if of sufficient duration and intensity, can lead to hearing damage, tinnitus, and eventual hearing loss. In this study, 30 music teachers were surveyed regarding their attitudes to music exposure, hearing protection, and symptoms of hearing damage. Pure tone audiograms were obtained for 28 participants. Results showed that teachers were aware of the risks associated with noise exposure, however, they believed that most of their teaching peers and students were less aware. The audiograms revealed reduced hearing acuity in 13 participants: Ten participants had average hearing levels >20-dB, and while this was age-appropriate for five participants, the other five had hearing worse than expected for their age. A further three participants had audiograms within the normal range (4FAHL < 20 dB HL), but thresholds were worse than expected for their age. Thus, in at least eight cases, there were possible indications of hearing loss that may be noise-related. This study suggests that music teachers are at greater risk of hearing damage than the general population. We

need to inform music teachers of the risk and encourage them to minimise their exposure levels in order to maintain their long-term hearing health.

Keywords: Music teachers, hearing damage, noise-induced hearing loss (NIHL), music-induced hearing loss (MIHL), hearing loss

Hearing is vital for musicians, and yet the act of making music may increase musicians' risk of hearing damage. The structures of the ear and the associated neural pathways that musicians use to detect tiny variations in pitch, volume, timbre and tone, can be damaged by exposure to excessive noise. The 'noise' generated by musicians, far from being unwanted, is usually a source of enjoyment for both performers and listeners. However, if it is of sufficient intensity and duration, this noise also has the potential to damage hearing.

In Australia (and many other countries), occupational standards require that an individual's noise exposure in the workplace is limited to 85 dB L_{Aeq} over an 8-hour period to minimise the risk of hearing damage. Noise exposure is dependent on a time/intensity relationship, such that a 3 dB increase in L_{Aeq}, reduces the allowable exposure time by 50%. Thus, 85 dB L_{Aeq} over 8 hours is equivalent to 88 dB L_{Aeq} over 4 hours, 91 dB L_{eq} over 2 hours, and so on. Noise exposure beyond these limits over a 40-year period will result in hearing loss for a substantial proportion of the exposed population.

Using these guidelines as a benchmark, researchers have measured professional and amateur, classical and non-classical musicians' noise exposure in a range of contexts, such as performance, practice, and tuition, to examine whether musicians' noise exposure is beyond occupational limits, and thus poses a risk to their hearing. Most studies have concluded that musicians in general are at heightened risk of hearing damage because of their consistently high levels of noise exposure (Barlow, 2010; Behar et al., 2004; Early & Horstman, 1996; O'Brien, Ackermann, & Driscoll, 2013; O'Brien, Wilson, & Bradley, 2008; Royster, Royster, & Killion, 1991). Musicians considered to be most at risk are brass players, percussionists and those who play amplified music (Hoffman, Cunningham, & Lorenz, 2006; Kähäri, Zachau, Eklöf, Sandsjö, & Möller, 2003; O'Brien et al., 2008).

A likely long-term outcome of accumulated excessive noise exposure is a permanent hearing loss. However, in the short- to medium-term, noise exposure can also result in conditions which are particularly disconcerting for musicians, such as tinnitus – a ringing or buzzing sound which occurs without an external stimulus, and hyperacusis – an intolerance of moderately intense sound stimuli (Anari, Axelsson, Eliasson, & Magnusson, 1999; Jansen, Helleman, Dreschler & de Laat, 2009). Numerous reports have shown that musicians' noise exposure increases the likelihood of developing these conditions, either with or without an associated hearing loss (Axelsson & Lindgren, 1981; Barlow, 2011; Chesky & Henoch, 2000; Kähäri et al., 2003; Ostri, Eller, Dahlin, & Skylv, 1989; Royster et al., 1991; Schink, Kreutz, Busch, Pigeot & Ahrens, 2014).

The noise exposure of music teachers is of particular interest because their teaching commitments provide them with regular, lengthy periods of music exposure. Despite this, there is only a small body of published research that looks specifically at the noise exposure and/or hearing status of music teachers, per se. For example, Zivokvic and Pityn (2004) measured the noise exposure of six Canadian school-based music teachers and found L_{Aeq}s ranging from 85-98 dB L_{Aeq}. Similarly, Behar et al. (2004) study of 16 Canadian music teachers reported L_{Aeq}s between 82 and 95 dB L_{Aeq}. The greatest noise exposure was during band teaching (84-98 dB L_{Aeq}) while noise levels during keyboard teaching ranged from 78-88 dB L_{Aeq}. Roggio et al. (2010) measured the noise exposure of piano teachers during lessons at a state music conservatory in Italy and found that noise levels ranged from 87.7 to 98.5 dB L_{Aeq}. Cutietta et al.'s (1994) study of 104 school-based music teachers found evidence of hearing damage in 34% of music teachers, more than half of which was considered to be noise-related. The effects of noise exposure were found particularly amongst high school band teachers compared to teachers with no experience of high school band teaching (Cutietta, et al., 1994), which is not surprising given the consistently high noise levels (around 90 dB L_{Aeq}) experienced by school band directors (Behar et al., 2004; Hayes, 2013; Owens, 2004).

In the current study, we sought to explore music teachers' attitudes towards music exposure; hearing protection; symptoms of auditory damage; perceptions of risk; and attitudes to noise reduction. We also measured the teachers' hearing thresholds to determine whether hearing acuity was poorer than what might be expected in the general population and whether exposure to noise might account for this difference.

METHOD

Participants

Ethics approval for this research was obtained from the Australian Hearing Human Research Ethics Committee. The study was conducted at a small music teachers' conference in Sydney, Australia. Conference attendees were invited to participate in a brief study on noise and hearing, comprising a survey and a hearing test. A total of 30 attendees (26 female; 4 male) agreed to take part. The participants were aged between 23 and 79, with a mean age of 51.3 years. Of these, 27 completed a hearing test and survey, two completed the survey only and one completed a hearing test only, that is, 29 completed a survey, and 28 completed a hearing test. Most participants were piano teachers (n=24). The remainder were teachers of voice (n=2) or amateur musicians employed in the music industry (n=4). Participants spent between two and 70 hours (overall mean = 26.3) in teaching, performance, practice and rehearsal per week. For full details of participants' current music-related exposures, please see table 1.

Insert Table 1 here

Survey

The authors developed a short survey which asked about attitudes to music exposure; hearing protection; symptoms of auditory damage; perceptions of risk; and attitudes to noise reduction.

At the end of the survey, participants were asked two questions designed to gauge their ability to make comparative risk judgements based on knowledge which underpins noise exposure allowances. We were interested to see if teachers would regard longer activities as more harmful, or the ones they thought were loudest, regardless of duration. The first question asked participants to consider which of the following posed the greatest risk to hearing: one hour at a nightclub or a two-hour trumpet lesson. The second question asked which of the following posed the greatest risk to hearing: one hour performing in a brass band or two hours watching a live gig with amplified music at a pub/club.

Hearing Test

A qualified audiologist conducted the hearing tests in a sound-treated music practice room with very minimal ambient noise. Prior to conducting the test, participants were questioned with regard to: hearing difficulties, family history of hearing loss, history of occupational and leisure noise exposure, exposure to blasts and impulse noise, past or current ear infections/dysfunction, and head trauma. All participants reported that they were well on the day of testing, and none had a pre-existing diagnosed hearing loss. Visual inspection by the audiologist confirmed normal appearance of the tympanic membrane in all but one participant, who was subsequently excluded from further analysis. Participants' pure-tone hearing thresholds at 0.5, 1, 2, 3, 4, 6, and 8 kHz were measured using an Interacoustics AA222 Audiotraveller diagnostic audiometer/impedance meter. To minimise any possible effects of ambient noise, insert earphones were used in accordance with international standards (ISO 8253-1, 2010) unless contraindicated. Attenuation of ambient noise was achieved with the use of noise-excluding ear muffs.

RESULTS

Survey Responses

Personal attitudes to music exposure. Most respondents (69%) did not believe that music exposure had damaged their hearing. However, the majority (72%) were concerned about the possibility of their hearing getting worse in the future. When asked to rate their personal risk of sustaining hearing damage from music and non-music-related activities (where 1 = no risk and 10 = high risk), the ratings were in the low-medium risk range. For music-related activities, the mean rating was: 3.5/10, and this did not differ significantly from the risk rating for non-music-related activities: 4.1/10, $t(27)=1.2$, $p>.24$.

Most respondents (90%) said that they were personally aware of the relationship between music-related activities and hearing damage, but when asked to consider the attitude of music teachers in general, only 38% believed that the majority of music teachers are aware of music-related hearing damage and take the issue seriously. There was overwhelming support (97% agreement) for the idea that all music students should receive training about protecting their hearing.

Symptoms of auditory damage. While most respondents reported no hearing problems after playing instruments, about one-third of respondents had experienced ringing in the ears (tinnitus), temporary hearing impairment, and/or blocked/sore ears. Most respondents (82%) agreed that if they developed tinnitus, they would start to think more seriously about protecting their hearing, although some commented that this might be leaving things too late.

Earplugs and other strategies. Most participants (69%) indicated that they would rather not wear earplugs when playing music. Respondents' overall attitude to using earplugs while playing music was rated at 3.9/10 (where 1 = negative and 10 = positive), and few had worn them while playing (only 14%). Those who had friends or colleagues who used earplugs rated earplugs more positively (mean rating: 4.8/10) than those who did not (mean rating: 3.2/10), but the difference was not significant, $t(26)=1.3$, $p>.22$.

Just over one-third of the group had thought about implementing some noise reduction strategies during teaching and/or playing, but a large percentage (59%) indicated that they were unsure where to start in terms of protecting their hearing. About one-third of respondents had tried strategies such as playing at lower volumes or using a barrier or shield to reduce noise exposure, although sometimes this was more about placating neighbours than reducing one's own exposure.

Risk Judgements. As shown in Table 2, participants were asked to compare one hour at a nightclub versus a two-hour trumpet lesson, and one hour performing in a brass band versus a two-hour live gig with amplified music at a pub/club. Using previously measured noise levels (Beach, Gilliver, & Williams, 2013), we calculated the noise exposure (in Pascal squared hours; Pa^2h) for each activity using the formula: $E_{A,T} = 4.T.10^{0.1(LAeq - 100)}$, (Standards Australia, 2005). Incidentally, all four activities exceeded 1.01 Pa^2h which is equivalent to the acceptable daily eight-hour workplace noise limit (85 dB L_{Aeq}).

Insert Table 2 here

In response to these risk judgement questions there were mixed results. As shown in Table 2, for the first question, the correct answer was nightclub, and most people (73%) gave the correct response. However, for question 2, the correct answer was performing in a brass band, but this time only 35% of people chose the correct answer.

Audiological Testing

Hearing Thresholds. Participants' hearing thresholds were examined to determine whether they met the criterion for hearing loss: a pure tone audiogram averaged across .5, 1, 2, and 4 kHz (4FAHL) that is greater than 20 dB HL in either ear. Participants' hearing thresholds at .5, 1, 2 and 4 kHz were averaged, and 10 of the 27 audiograms were found to be greater than 20 dB HL. Thus, 37% of participants were deemed to have a hearing loss. As shown in Figure 1, hearing loss was closely associated with age, and primarily seen in those aged 60 and above.

Insert Figure 1 here

Effects of age versus noise. To assess whether participant' audiograms were worse than might be expected for people their age, each participant's 4FAHL was compared to the corresponding 4FAHL set out in in the international standard (ISO 7029, 2000) for 'otologicially normal' non-noise exposed people aged 20-70. Of the 54 ears tested, 52 were worse than the median ISO threshold and 10 of the 56 were worse than the bottom 10% of audiograms in the ISO sample. See Figure 2 for a graphic representation of the female data. The 10 ears that fell below the bottom 10% were from eight individuals. Five of these people, aged between 57 and 73 years, were identified as having a 4FAHL >20 dB, and the remaining three participants whose thresholds were worse than expected for their age were between 26 and 31 years of age, but did not meet the criteria for hearing loss. Interview notes for the 13 participants with evidence of hearing damage were examined, and it was found that in four participants *non-music-related* risk factors (i.e., heredity hearing loss, head trauma, recent ear infections) may have contributed to their hearing test results. However, for the remainder, there were no other contributing risk factors except music teaching and performing.

Insert Figure 2 here

Summary. Overall, 13 of the 27 participants displayed some signs of hearing loss or damage. Five of these had age-appropriate hearing levels, but eight exhibited hearing loss greater than would be expected for their age. In four of the 13 participants, non-music-related risk factors may have contributed to the results, but for the remainder, the only risk factor identified was music teaching and performing.

DISCUSSION

The study's main finding is that although the teachers regarded themselves as being at low risk from their music-related noise exposure, the audiograms from 13 of 27 participants showed hearing loss. In five of these cases hearing thresholds were age-appropriate, but the audiograms of the remaining eight participants with hearing loss were worse than expected for their age. Although we cannot definitively exclude all other possible contributing factors, noise exposure from music-related activities may have had at least some effect on the hearing acuity of the 30% of the teachers whose hearing was poorer than expected for their age. These results are consistent with Cutietta et al.'s (1994) study, in which 34% of music teachers had hearing loss, and are not unexpected when one considers the amount of time participants spent in music-related activities. An average of 26 hours per week were spent teaching, playing and practising, with some teachers engaged in these activities for up to 70 hours per week. Although we did not measure actual noise exposure levels, results from other studies show that music teachers are routinely exposed to noise levels between 78 and 98 dB L_{Aeq} (Cutietta, et al., 1994; Roggio, et al., 2010). If music teachers are to reduce their risk by maintaining a noise exposure level that is below the acceptable occupational exposure limit, a teacher working an average 26-hour week would need to ensure that his/her noise level did not exceed 87 dB L_{Aeq}. They would also need to avoid any other significant noise exposures from other activities to reduce their risk of hearing damage. (See section on ***Noise Reduction Strategies*** for more information.)

In this study, the music teachers demonstrated a tendency to downplay the risk from their music activities. They perceived the risk from music-related activities to be similar to that from non-music related activities (3.5 vs 4.1 /10), despite most also saying they were aware of the relationship between music and hearing damage and were worried about the possibility of their hearing getting worse in future. Interestingly, the teachers in our study told us that they believed most teachers were unaware of the risks of noise damage and did not take the issue seriously. However, the risk ratings obtained here suggest that perhaps some of our participants could be described as relatively 'unaware' themselves. This attitude towards risk highlights a likely barrier to conveying a healthy hearing message to classical music teachers. As is the case in other health domains, awareness of personal risk is an important first step in taking preventative action to avoid adverse hearing outcomes (Bandura, 1998). If teachers do not perceive that music teaching poses a risk of hearing damage, they are likely to ignore or dismiss hearing health messages as 'irrelevant'. This suggests that in order to be effective, teachers will need targeted hearing health messages that incorporate themes and information that are directly relevant to the real-life risks posed by music teaching.

Further insight into teachers' attitudes to music-related risk were obtained from our analysis of participants' judgements of the relative risk from various musical activities. When considering the risk judgement questions, participants needed to weigh up two pieces of information: i) the typical noise level of each activity, and ii) the duration of the activity. In both questions, the shorter one-hour episode was the riskier activity. If participants had been responding on the basis of duration alone, they would have chosen the two-hour option in both questions, but only three people responded in this way. Rather, most people chose the activities they believed to be louder, and paid less attention to duration of activity. It is interesting that the most common response pattern – nightclubs and live gigs – were the options involving non-classical music. This response pattern likely indicates a belief that amplified (or youth-oriented) music is more damaging than more traditional or classical forms of music. This might reflect a more widespread attitude amongst the music fraternity (and the public generally) that classical music and related activities are inherently 'less harmful' than amplified music, even though there is ample evidence that orchestral musicians are exposed to excessive noise levels and are at heightened risk of hearing damage (O'Brien et al., 2008; Ostri et al., 1989; Schmidt et al., 2011)

Although it is true that classical music tends to be quieter than amplified music (Beach et al., 2013; Clark, 1991), and there is evidence that non-classical musicians are more likely to suffer from hearing loss than classical musicians (Chesky & Henoch, 2000), there is increasing overlap between classical and non-classical genre. Many musicians play across genres, and symphony orchestras play alongside amplified performers increasingly often. In addition to exposure during performances (whether classical or non-classical), virtually all musicians also spend many hours in practice, drilling, and rehearsals, all of which contribute to their overall cumulative noise exposure and increase their risk of hearing loss. O'Brien et al. (2013) recorded orchestral musicians' solo practice noise levels (L_{Aeq}) and found them to be between 60 and 107 dB, with an average daily exposure of 6.4 Pa^2h. Similarly, recent research from our laboratory, in which individuals' noise exposure was tracked over a five-day period, showed that the average daily noise level for musicians was 7.1 Pa^2h – over seven times the occupational noise limit – and posing a very real risk to hearing (Beach, Gilliver, & Williams, 2014).

In order to ensure that music teachers are fully aware of the risks inherent in performing and teaching music performing, it is imperative that hearing health and noise exposure are included in the training curriculum for new music teachers and professional development courses for practising teachers. The material should be offered to all teachers, classical and non-classical, studio- or school-based, and regardless of the instrument/s taught. In addition to presenting the usual information about ear anatomy, the physics of sound, and typical noise levels for particular instruments or genres, it may be particularly useful to show music teachers actual noise exposure plots which show how the noise exposure of *an individual* accumulates in the course of a typical day from activities such as teaching, solo playing, personal practice, or performing in various ensembles. Using real-world examples may assist teachers to develop an appreciation of the potential risk associated with their profession, which in turn may be an effective way of creating behaviour change. Such an approach may provide teachers with the opportunity to reflect on their daily noise exposures, identify those activities which contribute most to their noise exposure dose, and enable them to better manage their exposure patterns. Although further research is needed, in our experience, use of real-world materials such as individual noise exposure plots are an effective way of personalising noise risk and 'making the problem real' for those teachers who underestimate, or do not yet recognise, their own risk.

Increasing risk awareness in music teachers is essential, not only for conserving the hearing of teachers, but also for encouraging healthy hearing attitudes and protective behaviours in a new generation of student musicians before their noise exposure accumulates and symptoms arise. Music teachers are often highly regarded and well respected by their students and thus have the potential to exert a positive influence on students' hearing health by providing instrument-specific advice and relevant noise reduction strategies during lessons. This one-on-one 'grass-roots' advice would complement any formal instruction that may be provided by tertiary music schools. It is encouraging that recent developments, such as those in the US and Australia (Australian Government, 2012; Chesky, 2006), have seen tertiary music students being taught about hearing health and the risks of music exposure as part of an overall health and safety education program.

Noise Reduction Strategies for Music Teachers. Earlier we suggested that music teachers need to maintain safe noise exposure levels throughout their teaching day, and yet 59% of teachers told us they are unsure how to go about doing this. We have therefore included some practical strategies which music teachers can implement to lower their noise levels. (Further details can be found in Tattersall,2014; Zembower,2000; Plymouth City Council,2009; and Rawool,2012).

Any one of the following strategies either alone or in combination will have the effect of reducing a teacher's noise exposure level and thus reducing the risk of hearing damage. In order to reduce the reflection of sound, teachers might consider hanging drapes or thick curtains over hard surfaces such as blackboards, whiteboards or concrete walls. Installation of inexpensive textured acoustic panels or even home-made 3D relief art can absorb mid- and high-frequency reflections. Carpeting should be used on floors wherever possible, particularly in sections where teachers spend most of their lesson time. The simple act of stepping away from students can be an effective strategy because sound intensity diminishes with distance, and therefore moving away from students will reduce a teacher's noise exposure. Having less students in a class, and scheduling quiet breaks between lessons will also significantly reduce a teacher's noise exposure. By changing certain teaching methods teachers can also help reduce their exposure, for example, playing less often with students; using rhythm-clapping, note-naming, or singing where appropriate; using verbal discussion when there are notational or technical issues. In ensemble teaching, teachers can look for opportunities to improve the ensemble layout; introduce more individual and sectional playing; and avoid unnecessary ensemble playing.

Although some of these strategies may seem trivial, it should be remembered that a 3 dB reduction in noise level is equivalent to *halving* the sound pressure level, which can have a significant and positive impact on a teacher's overall exposure. To test the effectiveness of these strategies, teachers may wish to measure the actual noise levels during lessons by using a sound level meter application ('app'; see Kardous & Shaw, 2014 for a list of recommended apps). Not only will this provide an indication of the typical noise exposure level, it will also enable comparison of 'before' and 'after' measurements to see how effective the strategies have been in reducing noise levels.

Importantly, teachers with substantial teaching hours also need to think carefully about other noise exposures they may receive from non-teaching activities. For example, a teacher who also plays in an amateur ensemble, dances at nightclubs, listens to music through earphones at high volumes, rides motorbikes or motor scooters, should look at ways of avoiding and/or minimising their noise exposure from all of these sources, including the use of hearing protectors, such as earplugs, in high-noise situations.

Conclusion

The results reported here are from a small convenience sample, and are not intended to be representative of music teachers. However, the results raise issues which are likely to be of relevance to all music teachers. Most importantly, this study shows that, like other musicians, some music teachers may be at risk of hearing damage from the noise they and their students generate. Teachers need to be properly informed of the risk associated with their activities, and be provided with practical ways of mitigating the risk, so they can manage their noise exposure levels and teach a new generation of musicians to do the same.

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	Piano		Voice		Other		Ensemble		Total
	Perf (hrs/wk)	Tchg (hrs/wk)	Perf (hrs/wk)	Tchg (hrs/wk)	Perf (hrs/wk)	Tchg (hrs/wk)	Amplified (hrs/wk)	Non-amp (hrs/wk)	
Min	1	1	1	2	.5	6	1	1	2
Max	14	56	3	32	28	20	6	6	70
Mean	4.7	20.3	1.8	12	8	11	2.3	2	26.3

Table 1: Number of hours per week participants were engaged in music teaching (tchg) and performance (perf: includes practice and rehearsal).

Question 1			Question 2		
Options		% Correct	Options		% Correct
1 hour at nightclub (97.2 dB L_{Aeq}) [2.1 Pa^2h]	2-hour trumpet lesson (93 dB L_{Aeq}) [1.6 Pa^2h]	73%	1 hour performing in brass band (97 dB L_{Aeq}) [2 Pa^2h]	2 hours at live gig with amplified music at pub/club (92.4 dB L_{Aeq}) [1.4 Pa^2h]	35%

Table 2: Test of ability to make risk judgements. Noise levels shown in brackets are assumed noise levels for each activity based on previous measurements (Beach, et al., 2013). Values in square brackets are equivalent acceptable daily noise doses for each activity.

FIGURE LEGENDS

Figure 1. Median audiograms for those aged under 60 (upper panel) and those aged 60 and above (lower panel). Dots = minimum values, Triangles = maximum values, x= median values. Dotted line shows 20 dB hearing loss criterion.

Figure 2. Music teachers' 4FAHLs compared to the age-based 4FAHLs in ISO 7029. NB: This figure only shows age groups with 2 or more participants – all teachers represented are female.

Elizabeth Beach is a researcher at the National Acoustic Laboratories. She began working in the area of Hearing Loss Prevention in 2009 after completing undergraduate studies in Linguistics and Psychology and a PhD in Psychology. Her main area of research is leisure noise, its contribution to overall noise exposure and how it might be affecting our hearing acuity. She has a particular interest in noise exposure in the music and entertainment industries.

Megan Gilliver holds a B Sc (Psychology) and a Grad Dip (Linguistics). She completed her PhD in Psychology in 2006, and since 2007 has been working as a researcher at the National Acoustic Laboratories on a variety of projects. Her research interests include a focus on investigating factors which impact individuals' decisions to protect and maintain their hearing health.

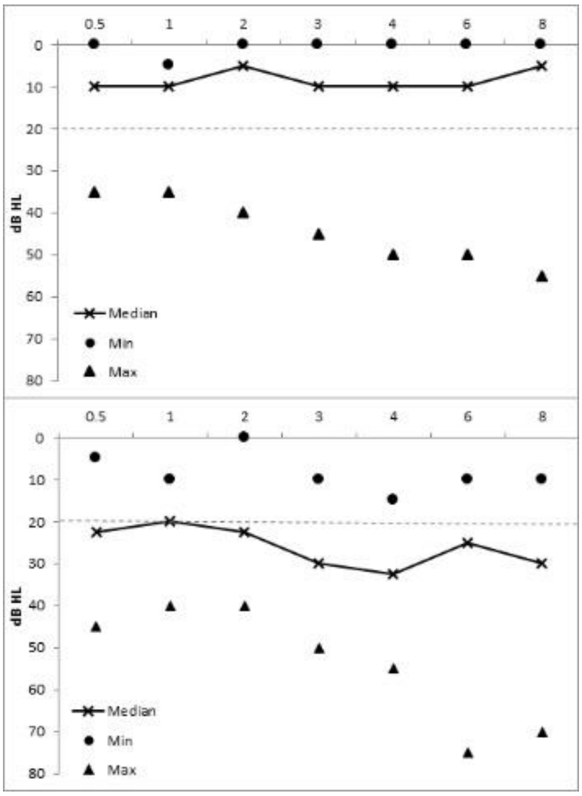

FIGURE 1

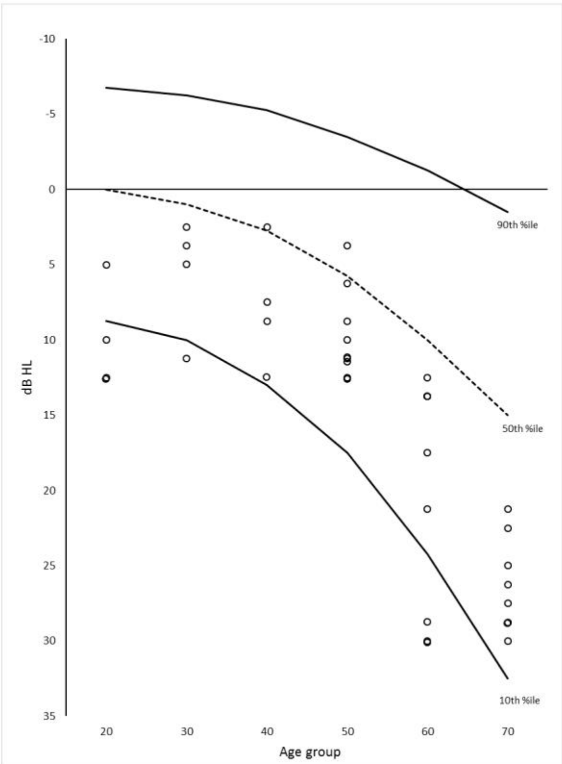

FIGURE 2