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Clinical dental noise and its association with the hearing thresholds of New Zealand dental students and clinical staff

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Abstract

Background: Although clinical dental noise within the Faculty of Dentistry at the University of Otago intermittently exceeds the permissible levels set by the New Zealand Occupational Health and Safety guidelines, its effects on the hearing thresholds of students and staff remain unclear. The aim of this study was to investigate and compare the hearing thresholds of dental undergraduate students and clinical staff members.

Methods: A total of 123 undergraduate dental students and 14 clinical staff members were recruited. Each participant undertook the uHear pure-tone hearing sensitivity test that evaluates the hearing threshold at 0.5, 1.0, 2.0, 4.0 and 6.0 kHz. Data were recorded and then analyzed using SPSS.

Results: No statistically significant differences were observed in the mean hearing thresholds of undergraduate students in years two, three, four and five at all frequencies examined. Clinical staff had significantly higher hearing thresholds than year-two students at all frequencies except for 4.0 kHz. Combined data from all groups found no sex differences in mean hearing threshold but higher mean hearing thresholds for the right ear were observed at 0.5, 1.0 and 2.0 kHz.

Conclusions: There did not appear to be significant differences in hearing thresholds between the second-, third-, fourth- and fifth-year undergraduate students. However, as clinical dental noise exposure could be considered a potential hazard, measures to increase student awareness and minimise exposure during clinical teaching should be implemented.

Introduction

Although we are constantly surrounded by background noise in our daily lives, it can become unpleasant or even disturbing for some individuals as its level increases. After an exposure to noise, the hearing threshold becomes temporarily elevated (temporary threshold shift) and recovers exponentially over a period of 2-3 weeks (Kujawa & Liberman, 2009). If the exposure is severe, the threshold may not recover completely and can stabilise at an elevated value, causing a permanent shift in hearing threshold (Kujawa & Liberman, 2009). Regular exposures at, or even below, a daily average of 85 dBA over 8 hours have been shown to induce permanent threshold shift via apoptosis and necrosis of the auditory hair cells of the cochlea as well as the loss of cochlear afferent neuron cell bodies (Franks et al., 1996; Kujawa & Liberman, 2009). Early noise-induced changes in hearing thresholds typically occur in the 3.0 to 6.0 kHz range and are likely to remain unnoticed by the affected individual until speech comprehension is affected (Thorne et al., 2008). Those with a noise-induced increase in hearing threshold (or hearing loss) commonly experience a lower sensitivity to high-pitched sounds as well as decreased clarity in their hearing in noisy environments. When tested in quiet conditions, this may manifest as normal hearing, a concept described as “hidden hearing loss” (Furman et al., 2013). These symptoms limit oral communication and can affect quality of life for those affected (Thorne et al., 2008).

It is well recognized within the dental profession that practising clinical dentistry exposes practitioners to a combination of noise from a variety of sources such as the high-speed dental turbine, low-speed dental turbine, high-velocity suction and ultrasonic instruments (Szymanska, 2010). Complaints regarding possible hearing disturbances attributed to the daily use of dental instruments are also common among dental practitioners (Gijbels et al., 2006). As early as 1959, the American Dental Association (ADA) recognized the potential hazards of this regular exposure to high frequency noise and recommended that all dental practitioners should undertake periodic hearing assessments to screen for hearing loss (Lopes et al., 2012). A further acknowledgement by the ADA in 1974 stated that the frequent usage of high frequency cutting instruments could lead to hearing impairments in dental practitioners (Willershausen et al., 2014).

Clinical dental noise and its effect on dental practitioners has been the focus of much research in the past decades. According to ISO1999, both the noise level and duration of exposure affect the overall severity of temporary threshold shift and recovery (International Organization for Standardization, 2013). In 1981, the sound levels generated by high-speed dental turbines were found to be between 70 and 92 dBA Sound Pressure Level (SPL) (Kilpatrick, 1981), thus potentially exceeding the 90 dBA United States Occupational Safety and Health Administration (OSHA) guideline described in 1970 and was associated with hearing loss and physiologic damage (Kilpatrick, 1981). In the same year, the OSHA reduced its recommended permissible noise level from 90 dBA to a safer level of 85 dBA (Franks et al., 1996). A similar study in 1999 measured even higher values between 95 and 115 dBA SPL for both the audible (<20 kHz) and ultrasonic (>20 kHz) frequencies (Barek et al., 1999). More recently in 2002, with relatively modern equipment, the noise generated during routine dental procedures was found to be 76-89 dBA SPL (Sorainen & Rytkönen, 2002). At these noise levels, sufficient daily exposure would put dental practitioners at a potential risk of permanent shifts in hearing threshold.

Although many follow-up studies have attempted to compare the hearing thresholds of dental practitioners to other populations, there is no consensus as to whether intermittent exposure to dental noise can lead to changes in hearing thresholds. Forman-Franco et al. (1978) carried out an audiometric survey of 70 dentists but found no differences in their hearing thresholds from a normal, age-adjusted population. A 15-year follow-up study of 68 dental practitioners in 1989 also failed to find any loss of hearing that could be attributed to dental noise exposure (Lehto et al., 1989). More recent studies, however, have suggested that the effect of dental noise on hearing thresholds remains controversial. Messano and Petti demonstrated that general dental practitioners who frequently use noisy equipment had a higher risk of hearing impairment than medical general practitioners (Messano & Petti, 2012). Willershausen et al. (2014) also concluded that exposure to dental noise can be an additional burden for the hearing of dental practitioners than for other professionals of similar age and environmental noise exposure.

To date, no studies have managed to identify a causal relationship between dental noise and hearing threshold changes in dental practitioners. Without a definitive conclusion, the question remains whether dental noise should be recognized as a potential health hazard for students and clinical staff within dental institutions. The noise levels in a typical undergraduate clinic can become very high because multiple dental units operate simultaneously and the hard interior surfaces increase the reverberant sound (Al-Dujaili et al., 2014). An investigation of dental noise at the Faculty of Dentistry at the University of Otago by Al-Dujaili et al. (2014) found that it intermittently exceeded the 85 dB SPL specified in the New Zealand Occupational Health and Safety guideline. Similar sound levels have been measured in dental schools in Portugal (60-99 dBA SPL) and India (64-97 dBA SPL) (Sampaio Fernandes et al., 2006; Kadanakuppe et al., 2011). However, the effect of dental noise exposure on the hearing thresholds of dental students during their undergraduate training is not well understood.

This study aimed to determine and compare the hearing thresholds of undergraduate dental students (year-two to year-five) and clinical staff members of the Faculty of Dentistry, University of Otago. A key distinction between this study and previous studies is the focus on undergraduate students, and their categorisation into year groups to evaluate possible effects of dental noise on the hearing threshold.

Materials and Methods

All research procedures were reviewed and approved by the University of Otago Ethics Committee and the Ngāi Tahu Research Consultation Committee prior to the commencement of data collection.

Those invited to participate were undergraduate Bachelor of Dental Surgery students and clinical staff members between the age of 18 and 65 years. Exclusion criteria included a history of pre-existing hearing impairment, chronic ear disease, ear trauma and ear surgery. A total of 125 undergraduate students and 14 staff members were recruited through posters and person-to-person communication to participate in the study. Participants received a detailed information sheet on the uHear smartphone application (Unitron, Victoria, BC, Canada) and completed a preliminary survey before giving written consent for a hearing assessment. All participants were given an identification code for anonymity and were free to withdraw from the study at any time.

The preliminary survey collected demographic information such as age, sex and academic position. Participants were asked to disclose any pre-existing conditions that could affect their hearing and comment on their perceptions of the effect of dentistry on hearing. Two of the 125 students reported a history of pre-existing hearing impairment and were thus excluded from the study. The final study group consisted of the remaining 123 students and 14 clinical staff, of whom 49 (35.8%) were male.

The uHear application v2.0.2 (Unitron, Victoria, BC, Canada) was run on an iPhone 5 (Apple Inc., Cupertino, CA, USA). uHear is a free iTunes application which has been previously validated as a screening test for hearing loss (Szudek et al., 2012; Peer & Fagan, 2015; Abu-Ghanem et al., 2016; Al-Abri et al., 2016). The application contains three modules: (1) a pure-tone air conduction hearing sensitivity test; (2) a speech in noise test; and (3) a questionnaire designed to create an individual hearing performance profile. For this study, the participants completed only the pure-tone hearing sensitivity test which determines the air conduction thresholds of the participant at 0.5, 1.0, 2.0, 4.0, and 6.0 kHz for each ear. It employs a 267 ms pulse duration with the “10 dB down and 5 dB up” approach and a randomised delay time between tones (Abu-Ghanem et al., 2016). The final hearing sensitivity is the lowest threshold with two positive responses of three excursions (Abu-Ghanem et al., 2016). The results of the test are grouped as per the American Speech Language Hearing Association (ASHA) categorisation. One aspect of the reported results that differs from the ASHA categorisation is that normal hearing and a slight hearing loss are combined into the same grade: normal = 0–25 dB, mild = 26–40 dB, moderate = 41–55 dB, moderately severe = 56–70 dB, severe = 71–90 dB and profound >91 dB (Abu-Ghanem et al., 2016).

Each participant took the uHear pure-tone hearing sensitivity tests in an unmodified room. A single set of Sennheiser CX300 earbuds (Sennheiser GmbH & Co., Germany) was used by all participants with appropriate

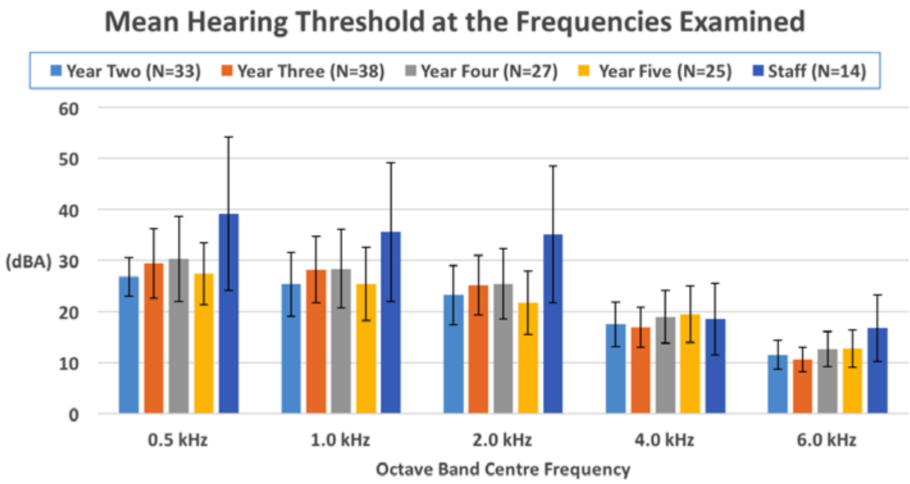

Figure 1

alcohol sanitisation between participants. Prior to each test, the ambient noise level present in the room was verified with the uHear application to be sufficiently quiet.

After the computation of descriptive statistics, differences in proportions were tested using chi-squared tests, and those observed in means were tested using analysis of variance (SPSS version 23, IBM, Chicago). Right- and left- side means were compared using paired t-tests. Regression analysis was used to estimate relationships in hearing thresholds of undergraduate students and other groups. A P value<0.05 was considered statistically significant.

Results

A total of 123 undergraduate students and 14 staff members completed both the preliminary survey and the audiometric screening test. The mean age of the participants was 23.5 years (SD: 6.8 years, range: 18–60 years). The hours of exposure to dental noise ranged from a mean of 6 hours per week for year-two students to 15 for year-five students. The clinical staff members working within the Faculty reported a range of exposure from 20 to 40 hours per week.

The results of the uHear audiometric screening tests are displayed in Figure 1. Since the year- two students had the least amount of cumulative dental noise exposure, they were used as the comparison group. No statistically significant differences were observed between the hearing thresholds of undergraduate students at different year levels. The clinical staff, however, had significantly higher hearing thresholds than year-two students at all frequencies examined except for 4.0 kHz, which was not statistically significant.

Summary data on hearing thresholds between right and left ears are shown in Table 1. The mean hearing thresholds for the right ear were found to be higher than the left at 0.5, 1.0 and 2.0 kHz with the largest difference in mean (3 dBA) at 0.5 kHz. When data from all participant groups were combined, no sex differences in mean hearing threshold was found at any of the frequencies examined.

Discussion

This study builds on a recent study of noise level in undergraduate clinics of the Faculty of Dentistry at the University of Otago (Al-Dujaili et al., 2014). Our findings suggest that dental noise-induced changes in hearing thresholds are unlikely to occur within the timeframe of undergraduate study and may take considerably more years of exposure to develop. The findings cannot be used to establish a cause-effect relationship between dental noise exposure and changes in hearing thresholds because the study was cross-sectional in nature.

The primary limitation of this study was that changes in hearing thresholds were estimated using uHear, and not with a formal audiogram. uHear has been validated as an audiometric screening test with a sensitivity of 98% (95% CI = 89-100) and a specificity of 82% (95% CI = 75-88) but it can be unreliable in determining exact hearing thresholds in the clinical setting (Szudek et al.,

Table 1. Mean difference in hearing thresholds (dBA) between the left and right ear

Frequency (kHz)	Mean Hearing Threshold		Mean Difference (SD)	P value
	Left Ear (SD)	Right Ear (SD)		
0.5	26.7 (12.6)	30.2 (13.9)	-3.5 (10.6)	0.001[a]
1.0	26.9 (8.4)	28.7 (9.7)	-1.8 (8.0)	0.010[a]
2.0	24.1 (9.1)	26.2 (10.4)	-2.1 (8.7)	0.007[a]
4.0	18.1 (4.1)	18.1 (3.9)	-0.7 (4.6)	0.867
6.0	12.0 (5.6)	12.5 (5.5)	-0.4 (6.4)	0.416

[a] Statistically significant with alpha value set at 0.05

2012; Al-Abri et al., 2016). A formal audiogram by an audiologist is the gold standard for measuring hearing thresholds, but it requires a specially designed facility and trained personnel (Abu-Ghanem et al., 2016), both of which were not achievable with the funding available for this study. We were, therefore, also unable to investigate the possibility of "hidden hearing loss" in any participants. Although age was a major confounder in the study, it was adjusted for during statistical analysis (Huang & Tang, 2010). In addition, because most undergraduate dental students were between 19 and 24 years old, age would have had a minimal effect on their hearing thresholds. With respect to the clinical staff however, the effect of presbycusis (gradual loss of hearing due to age) becomes much more important. It is possible that their higher hearing thresholds could be due to aging rather than exposure to dental noise (Huang & Tang, 2010). A further limitation is that the survey items used to estimate the level and duration of non-dental noise exposure were not validated. We were therefore unable to accurately evaluate the effect of non-dental noise on the participants' hearing thresholds without additional measurement data. Some participants had reported very high durations of non-dental noise exposures, making it possible that exposure to non-dental noise represented a larger risk to hearing than dental noise. Other risk factors for hearing loss (such as genetics and medications) can also have significant impacts on an individual's hearing threshold, but none of these could have been accounted for in this study (Huang & Tang, 2010). Although we obtained the participants' information regarding a pre-existing hearing impairment, chronic ear disease, ear trauma and ear surgery, we did not address the issue of a current cold. Middle ear effusion due to a cold can elevate low-frequency thresholds. Finally, we did not attempt to evaluate the participants' individual exposure to dental noise during a typical clinical session as our funding did not allow for the purchase of dosimeters. Instead, we have assumed that all students of the same year group had identical exposure to dental noise and were exposed continuously for the entire duration of their clinical sessions. Realistically, however, clinical dental noise would be intermittent rather than continuous, with exposure varying from day to day and among individuals (Al-Dujaili et al., 2014).

Many of the previous studies on this topic concluded that the noise from high speed dental air turbines is considered a low-risk exposure and may only induce gradual hearing loss in susceptible individuals after years or decades of exposure (Szymanska, 2010). This is consistent with our findings given that a meaningful difference in mean hearing thresholds was only observed between year-two students and the clinical staff members. The symptoms of noise-induced hearing loss, such as higher hearing thresholds, take many years to develop and are unlikely to be observed within the four years of the Bachelor of Dental Surgery program. To the best of our knowledge, there have been no published longitudinal or cross-sectional studies that focus on the hearing status of undergraduate students within a dental school. This lack of research reflects the difficulties in relating any observed changes in hearing thresholds to dental noise exposure. In our study, it was impossible to make the diagnosis of noise-induced hearing loss because the participants' hearing status before they began practising dentistry was not known. Any differences observed in hearing thresholds could therefore not be attributed to exposure to dental noise alone. Despite the difficulty in relating changes in hearing thresholds to dental noise exposure, some studies within the field have demonstrated that dental noise is an occupational hazard for dental professionals in the long term, with dental professionals experiencing higher risks of hearing impairment than medical general practitioners (Messano & Petti, 2012; Gurbuz et al., 2013; Baig & Aleem, 2016). A recent study of audiometric hearing thresholds levels among 53 dental practitioners and 55 other academic professionals concluded that dentists had poorer hearing at both 3.0 kHz and 4.0 kHz (Willershausen et al., 2014). It was also identified that such risks were not generalized to all dental practitioners, but were specific for those who frequently used noisy equipment (such as the high-speed dental turbine) in their daily practice. This higher risk was again reflected in the higher hearing thresholds observed in dental practitioners who frequently used noisy equipment than those who did not (Theodoroff & Folmer, 2015).

Interestingly, we have identified higher hearing thresholds in the right ear than the left at the lower frequencies of 0.5, 1.0 and 2.0 kHz, suggesting that dental students and staff members may be subjected to directional noise exposure. This unique directional pattern of hearing loss was not present among other professionals, but the finding differed from an earlier study which observed greater hearing loss in the left ears of right-handed dentists (Zubick et al., 1980; Willershausen et al., 2014). A difference in the hearing thresholds between the left and right ears could be explained by the position of high-frequency sound sources such as the high-speed dental turbines or ultrasonic instruments in relation to the practitioner's body. If so, the resultant increase in hearing thresholds would be found in the opposite ear of left-handed dentists to right-handed dentists. While this finding would merit further research, our study did not address the directionality of dental noise exposures.

Numerous previous studies (particularly those published in the 1970s) have also suggested that noise-induced hearing loss (NIHL) in dental practitioners tends to appear earlier in males than females, and it was suggested that the difference could be due to males being more susceptible (Lehto et al., 1989). By contrast, we found no sex differences in hearing threshold.

To determine the possible causal relationship between exposure to dental noise and hearing threshold changes in undergraduate dental students, hearing thresholds must be assessed longitudinally, and individual exposures to both dental and non-dental noise must be evaluated accurately. Audiometric evaluation for undergraduate students would need to be carried out after a clinical day, and again the following morning to identify any temporary threshold shifts and recoveries (Szymanska, 2010). Even so, it would still be challenging to distinguish between the contributions of dental noise and non-dental noise to any observed changes in hearing thresholds. It may also be beneficial to evaluate the hearing thresholds of new students entering the Bachelor of Dental Surgery program (before any exposure to dental noise) using a concurrent control group, such as the medical students. The data obtained could then be used as a reference point for any subsequent evaluations during both groups' undergraduate studies.

Although our study did not show that dental noise exposure within the Faculty of Dentistry caused any changes in the mean hearing thresholds of undergraduate dental students, it is still important for students to be aware of this potential risk factor. Clinical dental noise should be reduced where possible, because it currently intermittently exceeds the New Zealand occupational guidelines of 85 dBA. Various clinical techniques can be employed by dental students to minimize their individual exposure to dental noise. A working distance of around 35 cm (14 inches) from the dentist's eyes to the patient's mouth reduces the level of sound energy received (Kilpatrick, 1981). High sound level sources (such as high speed dental turbines or ultrasonic instruments) should only be activated just before they are used (Forman-Franco et al., 1978). For year-five students with longer clinical hours, it may also be beneficial to schedule patients in a way that allows breaks between the usage of high-speed dental turbines to reduce exposure to continuous dental noise.

In any new Faculty of Dentistry clinical building, it would be advantageous if the design of the undergraduate clinic included individualized surgeries, to avoid noise due to more than one high level sound source. Partitions separating surgeries should ideally be finished with sound-absorbing materials to reduce the reflection of sound energy (Szymanska, 2010). The new equipment should be of high quality, with regular maintenance as recommended by the manufacturer to maintain performance at minimum noise levels (Szymanska, 2010). Protective equipment (such as frequency response ear-plugs that reduce high frequency noise while allowing for normal conversations) should be made available for undergraduate students. In addition to hearing protection, they have been shown to facilitate better concentration on the work at hand by reducing the overall amount of background noise (Kramer, 1985). Finally, information on clinical dental noise and minimizing exposures should be incorporated into the undergraduate dental curriculum to help students recognize this potential hazard.

Conclusion

There did not appear to be significant differences in hearing thresholds between the second-, third-, fourth- and fifth-year undergraduate students. However, as clinical dental noise exposure could be considered a potential hazard, measures to increase student awareness and minimise exposure during clinical teaching should be implemented.

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References

Abu-Ghanem S, Handzel O, Ness L, Ben-Artzi-Blima M, Fait-Ghelbendorf K, Himmelfarb M (2016). Smartphone-based audiometric test for screening hearing loss in the elderly. *Eur Arch Otorhinolaryngol* 273: 333-9.

Al-Abri R, Al-Balushi M, Kolethekkat A, Bhargava D, Al-Alwi A, Al-Bahlani H, Al-Garadi M (2016). The Accuracy of IOS Device-based uHear as a Screening Tool for Hearing Loss: A Preliminary Study from the Middle East. *Oman Med J* 31: 142-5.

Al-Dujaili M, Thomson WM, Meldrum R, Al-Ani AH (2014). Noise levels in dental school clinics. *NZ Dent J* 110: 105-8.

Baig NN, Aleem SA (2016). Occupational Hazards Among Dental Surgeons in Karachi. *J Coll Physicians Surg Pak* 26: 320-2.

Barek S, Adam O, Motsch JF (1999). Large band spectral analysis and harmful risks of dental turbines. *Clin Oral Investig* 3: 49-54.

Forman-Franco B, Abramson AL, Stein T (1978). High-speed drill noise and hearing: audiometric survey of 70 dentists. *J Am Dent Assoc* 97: 479-82.

Franks JR, Stephenson MR, Merry CJ (1996). *Preventing occupational hearing loss – a practical guide.* DHHS (NIOSH) Publication No. 96-110. Cincinnati, Ohio: National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention U.S. Department of Health and Human Services.

Furman AC, Kujawa SG, Liberman MC (2013). Noise-induced cochlear neuropathy is selective for fibers with low spontaneous rates. *J Neurophysiol* 11: 577-86.

Gijbels F, Jacobs R, Princen K, Nackaerts O, Debruyne F (2006). Potential occupational health problems for dentists in Flanders, Belgium. *Clin Oral Investig* 10: 8-16.

Gurbuz MK, Çatli T, Cingi C, Yaz A, Bal C (2013). Occupational safety threats among dental personnel and related risk factors. *J Craniofac Surg* 24: e599-602.

Huang Q, Tang J (2010). Age-related hearing loss or presbycusis. *Eur Arch Otorhinolaryngol* 267: 1179-91.

International Organization for Standardization (2013). Acoustics — Estimation of noise- induced hearing loss. ISO 1999:2013(E). Retrieved from https://www.iso.org/standard/45103.html

Kadanakuppe S, Bhat PK, Jyothi C, Ramegowda C (2011). Assessment of noise levels of the equipments used in the dental teaching institution, Bangalore. *Indian J Dent Res* 22: 424-31.

Kilpatrick HC (1981). Decibel ratings of dental office sounds. *J Prosthet Dent* 45: 175-8.

Kramer R (1985). The dentist's health: high-speed rotary equipment as a risk factor. *Quintessence Int* 16: 367-71.

Kujawa SG, Liberman MC (2009). Adding insult to injury: cochlear nerve degeneration after "temporary" noise-induced hearing loss. *J Neurosci* 11;29(45):14077-85.

Lehto TU, Laurikainen ET, Aitasalo KJ, Pietilä TJ, Helenius HY, Johansson R (1989). Hearing of dentists in the long run: a 15-year follow-up study. *Community Dent Oral Epidemiol* 17: 207-11.

Lopes AC, Passarelli de Melo AD, Santos CC (2012). A study of the high-frequency hearing thresholds of dentistry professionals. *Int. Arch. Otorhinolaryngol* 16: 226-231.

Messano GA, Petti S (2012). General dental practitioners and hearing impairment. *J Dent* 40: 821-8.

Peer S, Fagan JJ (2015). Hearing loss in the developing world: evaluating the iPhone mobile device as a screening tool. *S Afr Med J* 105: 35-9.

Sampaio Fernandes JC, Carvalho AP, Gallas M, Vaz P, Matos PA (2006). Noise levels in dental schools. *Eur J Dent Educ* 10: 32-7.

Sorainen E, Rytkönen E (2002). Noise level and ultrasound spectra during burring. *Clin Oral Investig* 6: 133-6.

Szudek J, Ostevik A, Dziegielewski P, Robinson-Anagor J, Gomaa N, Hodgetts B, Ho A (2012). Can Uhear me now? Validation of an iPod-based hearing loss screening test. *J Otolaryngol Head Neck Surg* 41 Suppl 1: S78-84.

Szymanska J (2010). Work-related noise hazards in the dental surgery. *Ann Agric Environ Med* 7: 67-70.

Thorne PR, Ameratunga SN, Stewart J, Reid N, Williams W, Purdy SC, Dodd G, Wallaart J (2008). Epidemiology of noise-induced hearing loss in New Zealand. *N Z Med J* 121: 33-44.

Theodoroff SM, Folmer RL (2015). Hearing loss associated with long-term exposure to high-speed dental handpieces. *Gen Dent* 63: 71-6.

Willershausen B, Callaway A, Wolf TG, Ehlers V, Scholz L, Wolf D, Letzel S (2014). Hearing assessment in dental practitioners and other academic professionals from an urban setting. *Head Face Med* 18;10: 1.

Zubick HH, Tolentino AT, Boffa J (1980). Hearing loss and the high speed dental handpiece. *Am J Public Health* 70: 633-5.

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