Article

Is noise-induced hearing loss increased in dental clinicians who use the high-speed handpiece compared to dental professionals who use other noise inducing dental equipment?

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Introduction

Although modern dentistry is a technologically advanced field many hazards and occupational health issues are still present in terms of skin dermatitis, respiratory disorders, burns, eye injuries, psychological issues, exposure to infectious diseases, radiation and hearing issues.[1] Extended exposure to high noise levels by dental personnel may have a negative effect on hearing.[2] Noise is defined as unwanted and unpleasant noise, which may lead to a disruption of the balance or activity of human life.[3] Alongside noise encountered on a daily basis dental professionals are also subjected to noise within the workplace from various sources.[4]

Over exposure to hazardous sounds can result in tinnitus, hearing impairment and hearing loss, which can lead to other health complaints including hypertension, sleep disturbance, mental fatigue, nervousness, emotional frustration and general annoyance.[1] Tinnitus is the perception of sound in one or both ears in the absence of external stimulus.[5] Often, tinnitus precedes permanent hearing loss and can be an early warning sign of noise induced hearing loss (NIHL).[6]

The extent of hearing loss caused by noise is dependent on exposure to noise, frequency of the sound and intensity of the noise.[7] Sound intensity is measured in decibels (dB) with the greater intensity of the sound carrying the greater risk of hearing damage.[8] The Health and Safety Executive (HSE) for the United Kingdom (UK) noise regulations defines exposure action values as lower exposure action (80 dB or less for eight hours daily) and upper exposure action (85 dB or higher) where action such as using alternative processes are recommended when upper exposure action is noted.[9] Within the United States of America (USA) the recommended exposure to workplace noise by both the National Institute for Occupational Safety and Health (NIOSH) and Occupational Safety and Health Administration (OSHA) should not exceed 85 dB for eight hours and 100 dB for 15 minutes in order to minimise NIHL.[10]

Noise induced hearing loss

It is estimated that 250 million people worldwide suffer from disabling hearing loss with 16% of disabling hearing loss worldwide attributed to NIHL.[11] NIHL is the second most common occupational disease to affect the adult population.[3] Prevention of NIHL consists of the use of hearing protection devices (HPD) which can be active sound control or passive noise control.[2]

Noise inducing equipment in dentistry

Within dentistry several dental instruments are used which have varying levels of noise output.[12] Common types of noise inducing dental instruments including the high-speed handpiece, slow-speed handpiece, ultrasonic instruments and cleaners, mixing devices, high volume suction (HVS), compressors, stone mixers and model trimmers.[4] The noise produced by these instruments is also exaggerated by the hard surfaces used within dental environments, which act as noise reflectors.[13] The main noise inducing dental instrument to cause concern in relation to NIHL is the high-speed handpiece.[14] The high-speed handpiece is a precision instrument used for the efficient removal of tooth tissue and restorative materials without pressure, heat or vibration.[15] The first generation of the high-speed handpiece was first introduced in 1959 and has undergone many technological breakthroughs to reach the generation of high-speed handpiece which is used today.[2] Regardless of the technological breakthroughs the average noise level of the high-speed handpiece has remained relatively the same since the 1960s, with averages of 70–82 dB and peaks of 105 dB within the frequency range of 4,800–9,600 hertz (Hz).[14] Newer high-speed handpieces tend to produce sounds of less than 85 dB, however, aged and older high-speed handpieces are associated with the increased noise levels of 100 dB or above,[12] additionally, well maintained dental instruments produce reduced sound levels compared to instruments which are not well maintained.[16] The noise level of the high-speed handpiece also increases when used in cutting activities compared to not cutting, with cutting activities of handpieces reaching levels above 95 dB.[17] The high-speed handpiece uses water to cool the tip of the bur and prevent damage, therefore, requires the addition of high-volume suction (HVS) whilst in use which averages noise levels of 74–80 dB.[2]

Other noise inducing dental equipment within clinical areas including sterilisation areas include ultrasonic instruments such as the ultra-sonic scaler (USS) and ultrasonic bath.[17] The USS is a tool used to remove calculus from teeth and emits sound in the range of around 70–82 dBA, however, sound frequency of the USS is emitted at 25,000 Hz.[18] The ultrasonic bath is used to clean instruments prior to placing in the steriliser and produces sound in the range of 68–79 dB and a frequency of 37,000 Hz.[18]

Within prosthodontic dental laboratories equipment such as stone mixers, compressors and model trimmers are used, which produce noise levels in the range of 65–96 dB.[17] The stone trimmer produces the least noise and the compressor produces higher levels of noise.[17]

Dental personnel who use noise inducing dental equipment

Due to the versatility of the high-speed handpiece clinicians from all specialities in dentistry make use of them and they are reserved for use by members of the dental team classed as dental clinicians (DC), where removal of tooth tissue or restorative material is included within their scope of practice, including dentists and dental therapists.[15] Other dental professionals subject to using other noise inducing dental equipment include dental nurses (DN), dental technicians (DT), clinical dental technicians (CDT), orthodontic therapists (OT) and dental hygienists (DH).[19]

Rationale for research

In relation to NIHL within the dental profession there are limited guidelines available and minimal understanding of a progressive disease.[1] Although HSE in the UK and OHSA in the USA specifies recommendations for employees with exposures to 85 dB or higher for eight hours or over, within dentistry exposure to noise is usually smaller bursts of noise over time rather than eight continuous hours of constant noise.[2] It is imperative that dental professionals (DP) are aware of occupational noise and the adverse health consequences it can affect.[20]

Although there are a range of studies available which discuss occupational NIHL in dentists[4,12,21] there is no systematic review to date comparing NIHL in DCs who use the high-speed handpiece with other DPs.

This review critically appraises all current literature to assess if noise-induced hearing loss is increased in dental clinicians who use the high-speed handpiece compared to dental professionals who use other noise inducing dental equipment.

Method

A systematic review (SR) was undertaken following formulation of a clear and answerable research question and ethical clearance from the UCLan School of Dentistry's ethics lead. The review question was developed and framed using a concept framework (Table 1) and clear inclusion and exclusion criteria were defined (Table 2) leading to identification of keywords and synonyms for each main concept. Following scoping searches of the Cochrane database where no previous SRs were identified three key databases were searched, Medline with full text, Dentistry and Oral Science Source (DOSS) and Web of Science.

RefWorks was used to export citations from each database search and then was used to remove duplicate citations. A search of the grey literature and a hand search of the reference lists of articles identified through the database search was then performed.

Once duplicates were removed the title and abstracts of each citation were screened against the inclusion and exclusion criteria.

Search results

Initial searches identified 70 citations and once duplications were removed 58 citations remained. The titles and abstracts of the citations were screened by two reviewers against the inclusion and exclusion criteria for their relevance, which resulted in seven citations retained. The full text of these seven citations were obtained and reviewed by the same two reviewers where three citations were excluded, leaving four citations remaining to be included, which were all cross-sectional studies (see Figure 1 for PRISMA flow diagram).

Methodological quality assessment

Relevant data from each study was identified, extracted and critically appraised using the relevant Joanna Briggs Institute (JBI) critical appraisal tool (Table 3).[22] JBI is an international organisation which has developed unique evidence-based medicine information, software and education as well as offering a range of critical appraisal tools to support critical appraisal and to improve the practice of healthcare and outcomes to health.[22] The cross-sectional critical appraisal checklist developed by JBI uses a series of questions related to the study design where the answers available are yes, no, unclear or unapplicable.[22] Answering yes to a question shows increased quality and a lower risk of bias, whereas answering no or unclear relates to the methodological quality being lower and an increased risk of bias.[23]

Overall, although all four studies scored unfavourably for quality and bias in some areas all four studies were included within this review as limited evidence was found through the searches and this review aimed to assess all available evidence in relation to the topic area.

Data extraction and study characteristics and findings

In order to comprehend the data two reviewers identified, extracted and presented relevant data in a tabular format. Extracting data into a tabular format led to the development of summary tables of the main study characteristics, participants' characteristics and study findings of each study included (Tables 4, 5 and 6), which are used to aid in reporting and making sense of the data.[24]

Critical analysis of review findings

The findings of two studies indicated DN/As and DTs/prosthodontists suffered worse hearing thresholds than dentists[20,25] whilst findings from the remaining two studies indicated dentists were more prone to NIHL than other DPs.[26,27] The studies by Al-Omoush *et al.* (2019)[25] and Lopes, Passarelli de Mello & Santos (2012)[20] were larger scale studies than the studies by

Shetty *et al.* (2020)[26] and Theodoroff and Folmer (2015),[27] therefore, are more likely to hold the true result as the results of larger scale studies are more reliable.[28]

The only study to include a correlation analysis was Al-Omoush *et al.* (2019)[25] who found a statistically significant correlation between hearing thresholds and duration of noise exposure in the left ear of DTs at 4000 and 8000 Hz ($p = 0.039$ and 0.024 respectively) and in the right ear at 2000, 4000 and 8000 HZ ($p = 0.05$). However, within cross sectional research it is difficult to establish causation of an outcome even if a correlation is established, as correlation does not prove causation.[29] Therefore, the hearing loss experienced within the left ear of DTs cannot be explicitly linked to have been caused by the noise inducing equipment exposure.

Within the studies undertaken by Al-Omoush *et al.* (2019)[25] and Lopes, Passarelli de Mello & Santos (2012)[20] DTs and prosthodontists were in the groups with the worst hearing thresholds. Whilst there is limited research available comparing hearing thresholds amongst dental staff several studies have undertaken research into noise thresholds in different areas within dental settings.[16,30] Fernandos *et al.* (2006)[30] measured sound levels within five different clinical areas and laboratory areas and Choosong *et al.* (2011)[16] measured noise levels within dental clinics and one dental laboratory over a period of seven months. Both studies found that the nosiest working area over an eight hour period was the dental laboratory, which could explain why DTs were among the groups suffering worse hearing thresholds within the studies by Al-Omoush *et al.* (2019)[25] and Lopes, Passarelli de Mello & Santos (2012).[20]

Although Al-Omoush *et al.* (2019)[25] showed consistent statistically significant differences in the auditory thresholds in DTs and DAs compared to the control group ($p = <0.05$) the auditory range for all groups still fell within the normal hearing range with the dB range for the control group falling at the lower end of normal and the dB range for DTs and DAs falling within the higher end of normal.

Shetty *et al.* (2020)[26] provided no mean data, therefore, no assessment or critical analysis can be performed on the data. However, within the results the study stated PTA assessment found no significant hearing loss associated with dental speciality and OAE testing showing inner ear dysfunction in the specialisation of pedodontics for both left and right ears.[26] Shetty *et al.* (2020)[26] was one of two studies to break the study groups down into speciality, however noise exposure on a peadiatric clinic cannot be purely correlated to the high-speed handpiece owing to involvement of additional noise.[31] Jadid, Klein & Meinke (2011)[32] reported a range of exposures ranging from 94-112 dB on assessment of noise dosematry of residents within a paediatric clinic, which could account for the results.

Theodorff & Folmer (2015)[27] found significant difference in the mean threshold of all three groups for both ears between 3000–8000 Hz $p = <0.05$ with mean thresholds in the right ear for the DC group significantly worse compared to DP and DS groups for 4000 Hz and 8000 Hz and approached statistical significance at 3000 Hz compared to DP group $p = 0.055$ and DS group $p = 0.058$. Within the left ear significant differences were reported from 3000-6000 Hz between DC and DS groups and significant differences between DC group and DP/DS groups at 8000 Hz.[27] Additionally, Audiometric mean thresholds were not significantly different between the DP and DS group in either ear. Whilst the DS and DP groups hearing thresholds fell within normal hearing range the DC groups audiometry results fell into the higher end of mild to the lower end of moderate hearing loss.

Although Theodoroff & Folmer (2015)[27] concluded DCs who regularly use the high-speed handpiece had worse hearing than members of the other study groups there was no correlation tests performed to indicate if the high-speed handpiece is related to the audiometric findings and the mean age of the dental clinician group was higher than the other groups. Also, confounding bias may occur in cross sectional research when a variable is present associated with the exposure which could influence the outcome leading to a distortion between the exposure and outcome.[29] Theodoroff & Folmer (2015)[27] reported it was impossible to quantify the amounts of the exposures to other reported noise such as gunfire, indicated in the questionnaire for individuals or study groups. Lafoon *et al.* (2018)[6] studied audiometric findings within gunfire users concluding hearing thresholds were considerably worse in firearm users who seldom wore HPDs. Participants within the study by Theodoroff & Folmer (2015)[27] reported they ‘sometimes’ or ‘never’ wore ear protection in situations where gunfire was used, therefore, it is important to remember these may be a factor in the hearing loss exhibited by some participants within the study.

Within cross sectional research exposure and outcomes of the participants are measured at the same time.[29] In order to ensure validity and reliability it is essential that there is a clear description of the method of how the exposure was measured.[33] However, within all four studies the noise exposure was not fully investigated in order to give a clear picture of the type of noise inducing dental instrument used by each study group, especially as instruments are used for different durations depending on speciality.[20,25,26,27] There was a general assumption made within each study that the DCs groups used the high-speed handpiece and members of the other study groups used equipment related to their role on a regular basis, however, no investigation via questionnaire or observation was carried out to determine what type of instrument noise exposure occurred for each participant. Al-Omoush *et al.* (2019)[25] was the only study which detailed the age of the equipment used by participants within the study, however, no study included maintenance of equipment within the studies. Ahmed *et al.* (2013)[34] reported aged, worn out and handpieces which were not well maintained produced noise levels in excess of 100 dB, therefore, if any of the studies included participants who used aged and/or unmaintained equipment this could have impacted upon the results.

Out of the two studies which detailed hours of noise exposure this was taken as working hours with no breakdown of what percentage of the working hours the high-speed handpiece or other noise inducing dental equipment was used for within each day as within dentistry exposure to noise is usually smaller bursts of noise over time rather than constant noise over the period of a working day.[2] Also, there was no indication of how many days per week each participant was exposed to the environment of dental noise, which could have skewed the results as a participant who works part time will not be exposed to the same amount of noise over their working career as a full time worker.[9] Al-Rawi *et al.* (2019)[4] carried out a cross sectional study evaluating the hearing of 90 dental practitioners from different specialities in the United Arab Emirates (UAE) and found there was a direct relationship between hearing capacity and working hours per week.

Describing in detail the main features of the study sample included and the study setting is important for establishing if the participants in the study are comparable to the population of interest and aids in generalisability of the study findings.[35] Generalisability in this mini systematic review context refers to whether the findings can be transferable to the target population.[24] Selection bias occurs when the participant sample chosen is not representative of the target population.[29] Whilst the population in terms of participants recruited within all four studies were homogenous and representative of the target population with selection bias reduced, convenience bias could have occurred in the setting from which the participants were recruited, which could have impacted on the results of the studies.[36] Convenience bias occurs when participants are chosen from a population which is close at hand,[36] which in this case was generally dental academic institutes and hospital settings. Burk & Neitzel (2016)[37] undertook a study comparing noise exposures among dental staff and students within four large university dental schools with noise exposures of dental professionals working in private dental clinics with the use of dosimetry metres attached to 46 individuals. Results from the dosimetry readings showed 4% of participants exceeded the 85 dB over eight hours safety exposure limit with participants working on the dental school clinics exhibiting the higher average noise exposure levels.[37] Therefore, the results from studies only testing hearing of participants within educational settings should not be generalised to the target population outside of these settings.

Conclusion and recommendations

The aim of this mini systematic review was to assess if noise-induced hearing loss is increased in dental clinicians who use the high-speed handpiece compared to dental professionals who use other noise inducing dental equipment. After completing a systematic search and appraising the available evidence a firm conclusion cannot be reached due to the limitations and low quality of the evidence available. Two studies suggested NIHL was increased in dentists[26,27] while two studies suggested dental nurses/assistants and dental technicians had worse hearing thresholds than dentists.[20,25] However, due to the limitations with measurement of exposure within the studies the findings of all the studies need to be taken with caution as the hearing loss documented cannot be fully attributed to any particular noise inducing instrument. Although there was homogeneity among the studies in terms of the participant groups the findings of the studies were split and limitations were found within each study design which could have impacted on the results.

It is clear that noise exposure within dentistry is a concern, therefore, further high quality longitudinal studies are required where the exposure is clearly defined and detailed and baseline audiometric tests are undertaken then repeated at set intervals in order to fully assess if noise-induced hearing loss is increased in dental clinicians who use the high-speed handpiece compared to dental professionals who use other noise inducing dental equipment. It was hoped that recommendations could be made on which dental personnel would benefit from the use of preventative measures, mainly HPD. However, due to the low quality and limitations within the available evidence specific recommendations cannot be made for groups of dental personnel. However, recognition should be directed to all dental personnel regarding the amount of noise they are exposed to within the working environment and through specific instrument use, which may include the types of treatments that are booked in, the age of the instruments in use and if the instruments are well maintained. This recognition should influence the need for HPD in the form of either passive or active earplugs to become an essential consideration for personal protective equipment (PPE) within dentistry.

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TABLE 1: CONCEPT FRAMEWORK

	Main concept
Concept 1	Exposure - Noise inducing dental instruments
Concept 2	Population 1 - Clinicians who use the high-speed handpiece
Concept 3	Population 2 - Dental professionals who use other noise inducing dental equipment
Concept 4	Outcome - Noise induced hearing loss

TABLE 2: INCLUSION AND EXCLUSION CRITERIA

Inclusion	Exclusion
All study designs which compare PTA hearing thresholds among dental clinicians/professionals	Studies comparing hearing loss in dental clinicians/professionals to other professions
Evidence from peer reviewed and non-peer reviewed journals	Studies which include dental clinicians/professionals diagnosed with a hearing impairment
	Studies which compare sound levels near participants ears rather than audiometric testing
	Studies which use HFA or OAE only without PTA

TABLE 3: METHODOLOGICAL QUALITY ASSESSMENT

	Al-Omoush et al, 2019	Lopes, Passarelli de Melo & Santos, 2012	Shetty et al, 2020	Theodoroff and Folmer, 2015
Were the criteria for inclusion in the sample clearly defined?	Yes	Yes	Yes	No
Were the study subjects and the setting described in detail?	Unclear	Unclear	Unclear	Unclear
Was the exposure measured in a valid and reliable way?	Unclear	No	Unclear	No
Were objective, standard criteria used for measurement of the condition?	Yes	Yes	Yes	Yes
Were confounding factors identified?	No	Yes	No	Yes
Were strategies to deal with confounding factors stated?	Not applicable	No	Not applicable	No
Were the outcomes measured in a valid and reliable way?	Yes	Yes	Yes	Yes
Was appropriate statistical analysis used?	Yes	Yes	Yes	Yes
Overall appraisal:	Include	Include	Include	Include

TABLE 4: STUDY CHARACTERISTICS TABLE

	Al-Omoush et al, 2019	Lopes, Passarelli de Melo & Santos, 2012	Shetty et al, 2020	Theodoroff and Folmer, 2015
Type of study	Cross Sectional Study	Cross Sectional Study	Cross sectional exploratory study	Cross sectional pilot study
Country	Amman, Jordan	Sõa Paulo, Brazil	Karnataka, India	Oregon, USA
Setting	University Hospital	Private dentistry offices and laboratories Dental Universities Dental Hospitals	Dental College	University Dental School
Aim of Study	To evaluate the hearing threshold of dentists and other dental personnel including dental technicians and dental assistants.	To investigate the auditory thresholds of dentists, dental nurses and prosthodontists	To assess the hearing ability of dental personnel working in Yenepoya University, India	To record and compare audiometric pure tone thresholds of dental clinicians, dental professionals and dental students.
Sample size	Total number - 244	Total number - 108	Total number - 60	Total number - 37
Dental Professions Included	Dentists Dental Technicians Dental assistants Fifth year dental students Control group of third year dental students	Dentists Dental nurses Prosthodontists	Dentists - subgroups prosthodontics conservative endodontics periodontics pedodontics Dental technicians	Dental clinicians (dentists) Dental professionals Dental students
Methods	Questionnaire and audiometric testing	Interview, audiometric testing, speech reception threshold tests and acoustic impedance testing.	Audiometric testing	Questionnaire and audiometric testing Sound intensity testing of dental instruments close to each clinician's ear.
Examination prior to Audiological Testing	Examined otoscopically using a monocular	Middle ear inspection	Screened using otoscopic examination and Weber	No

	otoscope and used tympano-metric testing		test	
Audiometric Testing	Pure tone air-conduction audiometry	Conventional pure tonal threshold audiometry (250 – 8000 Hz) and high frequency tonal threshold audiometry (9000 – 16000 Hz)	Pure tone audiometry and Otoacoustic emission	Pure tone Audiometry
Frequencies tested	250, 500, 1000, 2000, 4000 and 8000Hz	250, 500, 1000, 2000, 3000, 4000, 6000, 8000, 10,000, 12,500, 14,000, 16,000 Hz	250, 500, 1000, 2000, 4000, 6000 and 8000 Hz	500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz
Statistical analysis	Three factor ANOVA and t-tests	Kruskall-Wallis test and Dunn test	Two-way ANOVA and Statistical Package for Social Sciences (SPSS) software	2-tailed t test, a 1 way ANOVA and a bonferroni correction

TABLE 5: STUDY PARTICIPANTS TABLE

	Al-Omoush et al, 2019	Lopes, Passarelli de Melo & Santos, 2012	Shetty et al, 2020	Theodoroff and Folmer, 2015
Dental profession	39 Dentists 28 Dental Technicians 23 Dental assistants 92 Fifth year dental students 62 Control group of third year dental students (% not supplied)	44 Dentists 36 Dental nurses 28 Prosthodontists (% not supplied)	48 (80%) Dentists - subgroups prosthodontics 19 (31.7%) conservative and endodontics 12 (20%), periodontics 10 (16.7%) pedodontics 7 (11.7%) 12 (20%) Dental technicians	16 Dental clinicians (15 dentists, 1 prosthodontist) 13 Dental professionals (professions not listed – did include radiologists and clinical administrators) 8 Dental students (% not supplied)
Participant gender	Dentists M=21, F=18 Dental Technicians M=23, F=5 Dental assistant M=1, F=22 Fifth year dental students M=30, F=62 Control group of third year dental students M=20, F=42 (% not supplied)	Dentists M=16, F=28 Dental nurses M=0, F=36 Prosthodontists M=17, F=11 (% not supplied)	M=30 (50%), F=30 (50%)	Dental clinicians M=16, F=0 Dental professionals M=4, F=9 Dental students M=5, F=3 (% not supplied)
Participant age (years)	Dentists 24–40 (mean 28.8) Dental Technicians 25–44 (mean 33.5) Dental assistants 21–44 (mean 34.4) Fifth year dental students	Dentists 23 – 57 (mean 34) Dental nurses 21 – 59 (mean 38) Prosthodontists 17 – 53 (mean 35) (% not supplied)	Age range 20 – 55 with mean age 35.2 years 20-25 – 7 (11.7%) 26-30 – 12 (20%) 31-35 – 16 (26.7%) 36-40 – 11 (18.3%) 41-45 – 6 (10%)	Dental clinicians mean age 53.5 (SD 12.0) Dental professionals mean age 47.3 (SD 11.5) Dental students mean age 28.9 (SD 3.4)

	21-24 (mean 22.7) Control group of third year dental students 20.7 (mean 20.7) (% not supplied)		46-50 – 6 (10%) 51-55 – 2 (3.3%)	(% not supplied)
Participant years of experience	Dentists 3-19 years (mean 6.12) Dental technicians 3-24 years (mean 10.42) Dental assistants 1-23 years (mean 11.91) (% not supplied)	At least 2 years' experience (mean 35 years across all 3 groups)	0-30 years (mean 11.9) 0-5 – 8 (13.3%) 6-10 – 26 (43.3%) 11-15 – 11 (18.3%) 16-20 – 6 (10%) 21-25 – 6 (10%) 26-30 – 3 (5%)	2.8 – 22.3 years
Participant Exposure per day	Dentists 3-5 hours (mean 3.44) Dental technicians 3-6 hours (mean 4.25) Dental assistants 2-5 hours (mean 4.46) (% not supplied)	Exposure not specified	6-15 hours (mean 7.9) 0-5 – 0 (0%) 6-10 – 52 (86.7%) 11-15 8 (13.3%)	Not specified

TABLE 6: STUDY FINDINGS TABLE

	Al-Omoush et al, 2019	Lopes, Passarelli de Melo & Santos, 2012	Shetty et al, 2020	Theodoroff and Folmer, 2015
Questionnaire findings	<u>Asking others to repeat what they have said</u> 46% dentists 55.3% dental technicians 64.4% dental assistants 21.7% 5th year dental students 10.5% 3rd year dental students <u>Hearing issues in noisy places</u> 50.8% dentists 60% dental technicians 75.6% dental assistants 18.8% 5th year dental students 9.4% 3rd year dental students <u>Need to pay extra attention to understand what others are saying</u> 41% dentists 52% dental technicians 60% dental assistants 20.4% 5th year dental students	N/A	N/A	Many study participants reported histories of significant exposure to loud sounds outside of the dental clinic. Some participants reported being exposed to recreational noise. Participants reported that they “sometimes” or “never” wore ear protection in those situations

	9.2% 3rd year dental students			
Interview findings	N/A	65 bothered by noise at work 50 reported difficulties in speech comprehension 8 had served in the army 11 had acoustic trauma 32 were exposed to chemical products 35 referred to being exposed to noise during recreational activities	N/A	N/A
Audiometric findings	Consistent statistically significant differences auditory thresholds in dental technicians and dental assistants as compared to the control group at all tested frequencies in both ears (p=<0.05) - exception of the right ear of dental assistants at 1000Hz (p=<0.05) *Full mean data in data extraction table No statistically significant correlation found between hearing thresholds of dentists and 5th year dental students.	**Right Ear:** 2000 Hz (p=0.0446), 8000 Hz (p= 0.0492) 16,000 Hz (p=0.0441) when comparing mean of group 1 (dentists) 2000Hz – 6dB 8000Hz – 12dB 16000Hz - 22dB to the mean of group 2 (dental nurses) 2000Hz – 10dB 8000Hz – 19dB 16000Hz – 33dB **Left Ear:** 3000 Hz (p=0.0147), 4000 Hz (p=0.0238) 6000 Hz (p=0.0310) when comparing the mean of	Marginally statistically significant results at 250 Hz for the left ear p=0.039 with overall no significant hearing loss associated with dental speciality. OAE test result anaylsis showed values less than 6 for majority of frequencies in the specialisation of pedodontics for both left and right ears, indicative of inner ear dysfunction. *No mean data given	Significant difference in the mean threshold of all 3 groups for both ears 3000 – 8000 Hz p=<0.05 **Right Ear:** Mean thresholds DC group significantly worse compared to DP and DS groups for 4000 Hz and 8000Hz and approached statistical significance at 3000 Hz (compared to DP group p=0.055 and DS group p=0.058). DC – 3000Hz 30dB 4000Hz 38dB 8000Hz 42 dB DP –

	*Pearsons correlation used – correlation coefficient not specified	group 1 (dentists) 3000Hz – 8dB 4000Hz – 9.5dB 6000Hz – 15dB to the mean of group 2 (dental nurses) 3000Hz – 13dB 4000Hz – 15dB 6000Hz – 20dB and to the mean of group 3 (prosthodontists) 3000Hz – 12dB 4000Hz – 15.5dB 6000Hz – 22dB 9000 Hz (p= 0.0397) when comparing the mean of group 1 (dentists) 9000Hz – 11dB to the mean of group 3 (prosthodontists) 9000Hz – 19dB. *Full mean data in data extraction table		3000Hz 10dB 4000Hz 16dB 8000Hz 19dB DS – 3000Hz 7.5dB 4000Hz 14dB 8000Hz 13.5dB **Left Ear**: significant differences from 3000 Hz – 6000 Hz between DC and DS groups DC – 3000Hz 28dB 4000Hz 36dB 6000Hz 31dB DS – 3000Hz 6.5dB 4000Hz 11 dB 6000 Hz 6.5dB significant differences between DC group and DP/DS groups at 8000 Hz. DC – 8000Hz 41dB DP – 8000Hz 19dB DS – 8000Hz 15dB Audiometric mean thresholds were not significantly different

				between the DP and DS group in either ear. *Full mean data in data extraction table
Additional findings	Statistically significant correlation between hearing thresholds and duration of noise exposure in the left ear of Dental Technicians at 4000 and 8000 Hz (p=0.039 and 0.024 respectively) and in the right ear at 2000, 4000 and 8000 HZ (p=0.05) *Pearsons correlation used – correlation coefficient not specified	Right and left ear presented similar configurations in conventional and high frequency audiometry when the mean hearing threshold for all groups is considered.	As working experience increases, a statistically significant threshold shift is seen from 4000 to 6000Hz, which is indicative of sensorineural hearing loss due to noise-induced dental environment. As age increases a significant threshold dip was observed at 6000 and 8000 Hz in the age group 51 – 55 suggestive of presbycusis. No statistically significant difference was found between mean daily working time and gender.	The use of Hearing protective devices was rare with 1 DC, 0 DP and 1 DS reporting they used earplugs in the workplace.
Conclusion	Dental assistants and dental technicians were found to be the relatively most affected by noise	Conventional hearing assessment did not identify hearing issues in the 3 groups tested,	Dentists had more inclination towards hearing loss compared to dental technicians.	Dental clinicians who regularly use the high-speed handpiece had worse hearing than

	pollution among the dental team.	however, prosthodontists had the worst hearing threshold. Dental nurses revealed the worst hearing thresholds in the high frequency mean comparison.	Dentists working in pedodontics were more prone to hearing loss compared to other specialisations.	members of the other study groups. Clinicians who operate dental handpieces are at risk of developing NIHL.

FIGURE 1: PRISMA FLOW DIAGRAM