ORIGINAL ARTICLE
ISSN 2645-4351
https://doi.org/10.22037/jds.v43i3.46472

Early Detection of Occupational Noise-Induced Hearing Loss in Dentists: A Cross-Sectional Study

Hadi Ghasemi[a*], Seyyed Jalil Mirmohammadi[b], Arezoo Ebn Ahmadi[c], Atefe-alsadat Tabatabaei[a]

[a]Department of Community Oral Health, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
[b]Department of Occupational Medicine, School of Medicine, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.
[C]Project Management Office, Inspirata Incl., Toronto, Canada.
***Correspondence to Author, Hadi Ghasemi, Email:** ha.ghasemi@sbmu.ac.ir

Submitted: 16 November 2024
Revised: 03 March 2025
Accepted: 16 March 2025
Published: Summer 2025

How to cite:
Ghasemi H, MirMohammadi SJ, EbnAhmadi A, Tabatabaei A. Early Detection of Occupational Noise-Induced Hearing Loss in Dentists: A Cross-Sectional Study. J Dent Sch 2025;43(3):121-127.

Abstract:

Objective(s): Noise-induced hearing loss (NIHL) is a critical occupational hazard, particularly among dentists exposed to high-frequency sounds from dental equipment. This study aimed to assess hearing thresholds in dentists using Pure Tone Audiometry (PTA) and High-Frequency Audiometry (HFA). **Methods:** A cross-sectional study was conducted with 63 dentists in Yazd, Iran, who underwent audiometric testing across frequencies ranging from 250 Hz to 16,000 Hz. Dentists over 50 years old and those with a history of hearing problems or ototoxic drug use were excluded. Statistical evaluation included independent t-tests, ANOVA, Pearson's correlation coefficient, and Chi-square tests at a significance level of 0.05. **Results:** hearing loss was most prevalent at 4,000 Hz in the normal frequency range, affecting 35% of participants in the right ear and 33% in the left ear. High-frequency hearing loss was significantly higher, with 86% of dentists exhibiting hearing loss at 16,000 Hz in the right ear and 79% in the left ear. The study also found a significant correlation between hearing thresholds, age, and work experience, emphasizing the increased risk of NIHL with prolonged exposure to dental equipment noise. Gender differences were noted, with men showing higher rates of hearing loss at 4,000 Hz. **Conclusion:** These findings underscore the necessity for regular auditory screening and the implementation of protective measures in dental practice to prevent long-term hearing damage. The study highlights the utility of HFA for early detection of NIHL, especially in high-risk professions like dentistry.

Keywords: Hearing Loss; Noise-Induced; High-Frequency; Dentists; Audiometry; Occupational Exposure

Introduction

Noise exposure poses various health risks to humans, with noise-induced hearing loss (NIHL) being one of the most significant.[1] While sound intensities as high as 130 decibels (dB) can cause ear pain, hearing damage can occur even at lower levels. Given that dentists are regularly exposed to high-frequency sounds generated by dental equipment, it is essential to monitor their hearing health.[2]
To better understand audiometry terminology, it is important to note that Hertz (Hz) is the unit of frequency, representing the number of sound wave cycles per second. Frequency determines the pitch of a sound, with higher frequencies corresponding to higher pitches. dB is the unit used to measure sound intensity or loudness, which is the power per unit area carried by a sound wave. Sound intensity refers to the amount of energy transmitted through a unit area in a specific direction, and it is directly related to the perceived loudness of a sound.[3] Together, these concepts help quantify the characteristics of sound, which are critical in understanding NIHL.
Traditionally, audiometry measures hearing thresholds at frequencies below 8,000 Hz. However, since the human ear can detect sounds up to 20,000 Hz, recent studies recommend extending audiometric testing to higher frequencies (above 8,000 Hz) for the early detection of NIHL.[4] In dental practices, common equipment such as saliva ejectors, older handpieces, power suction devices, and stone cutters generate sound intensities ranging from 75 to 92 dB at a distance of one meter from the operator's ear.[5]
Studies show that hearing damage starts in people exposed to noise above 85 dB and 4000 Hz [6], and exposure to noise for more than 10 years significantly increases the probability of NIHL.[7] In another study in 2011, Kadano Kuppe and colleagues investigated the amount of sound created by different dental devices and equipment and finally, they determined that dentists who spend the whole day in the workplace are at risk of getting NIHL, making periodic audiometry necessary for these people.[8] Fazli et al. showed hearing loss in both right and left ears of dentists in Zanjan, Iran. This hearing loss was higher in frequencies outside the conversation and in the left ear. In both ears, women's hearing loss was less than men. In both ears, the hearing loss of people 40 years old and higher was more than that of below 40 years old, and hearing loss had a direct relationship with work history. Based on the sound measurement results of that study, the noise caused by the devices was determined to be between 70 and 105 dB.[9]
Efforts to detect early hearing loss and the prevalence of hearing changes even in the absence of complaints have led to the development of high-frequency audiometry

(HFA) as a method for determining hearing thresholds.[4] The validity of HFA for determination of hearing loss has been suggested.[10] Some studies have shown a higher sensitivity of hearing loss in the high frequency range of 10,000 to 20,000 Hz.[11, 12, 13]

The present exploratory study aimed to assess hearing thresholds in dentists using Pure Tone Audiometry (PTA) and High-Frequency Audiometry (HFA). While the findings may not be generalizable to all dental professionals due to the study's cross-sectional design and sampling from a single city, they provide valuable insights into the auditory health of dentists exposed to occupational noise, highlighting the need for further research in diverse settings.

Methods

Participants of this cross-sectional study were a convenient sample of 63 dentists working in the city of Yazd, Iran. Assuming the approximate prevalence of hearing loss among dentists to be 35% based on a previous study [14], with a margin of error of 10% (d) and a confidence level of 95% (Z), a statistical power of 80%, with an effect size of 0.5, which is considered moderate, the required sample size for this study was calculated using the standard sample size calculation formula for prevalence studies [15]:

$n=Z^2p(1-p)/d^2= (1.96)^2\times 0.35\times 0.65/ (0.01)^2\approx 88$,

Considering the total population of dentists in Yazd as a relatively small number (e.g., N=200), the finite population correction formula was applied to adjust the sample size to 63 as follows:

$n_{adjusted}= n/1+(n-1/N)= 88/1+(88-1/200) \approx 63$

The process of data collection was completed during June to July 2014. The participants were informed about the anonymity and voluntarily nature of the study, its objectives, and process and confidentiality of their responses. The ethical concerns of the study were reviewed and approved by the department of Community Oral Health, Shahid Beheshti School of Dentistry.

After obtaining written informed consent, the participants were asked to complete a questionnaire inquiring about their gender, age, being cigarette smoker, years in dental practice, history of hearing problems, exposure to noise outside the work environment, use of ototoxic drugs, and use of hearing protection devices during work. All dentists were then subjected to conventional PTA using audiometer AC 40 with earphone TDH 39 as well as HFA using the same device but with earphone R80.[16] Both examinations were conducted in an acoustic chamber meeting criteria of ANSI 2004 in the same situation and by the same audiologist. Audiometry was conducted at frequencies of 250, 500, 1000, 2000, 3000, 4000, 6000, 8000, 10,000, 12,000, 14,000, and 16,000 Hz for both the right and left ears, and the hearing thresholds were recorded.

Dentists who reported history of acoustic trauma, taking ototoxic drugs, prolonged exposure to noise outside the work environment, infection or previous hearing problems, and more than 50 years old were not included in this study.

Descriptive statistics included reporting mean, frequencies, and percentages. For the comparative analysis, an independent sample t-test was performed to evaluate the difference in mean hearing thresholds between normal and higher frequencies. An ANOVA test was utilized to analyze variations in mean hearing thresholds across different frequencies, followed by Tukey's Honestly Significant Difference (HSD) post-hoc test to identify specific differences between frequencies. To explore the relationship between hearing thresholds and variables such as age and work experience, Pearson's correlation coefficient was calculated. Normality of the data was confirmed using the Shapiro-Wilk test, and homogeneity of variance was verified using Levene's test. Both assumptions were met for the independent t-tests, ANOVA, and Pearson's correlation coefficient. The Chi-square test and Fisher's exact test (for subgroups with expected frequencies <5) were used to assess the distribution of hearing loss across gender categories.

Hearing thresholds at various frequencies were calculated, followed by the determination of hearing loss frequency, defined as thresholds exceeding 25 dB at each frequency.[17] The relationships between the frequency of hearing loss and demographic variables such as age, gender, and work experience were subsequently analyzed. The data was analyzed using SPSS 19 software at a significance level of 0.05.

Results

The mean age of participants was 36.2 years (SD=±4.7). They had an average work experience of 8.6 years (SD=±3.8), ranging from 1 to 17 years. Table 1 presents the distribution of dentists based on demographic and practice-related factors. Among the participants, 54% were male and the majority were younger than 40. Regarding the work experience, 79% of the dentists had more than five years of experience and 81% worked for more than four hours per day.

Table 2 shows the mean hearing thresholds at normal frequencies for both the right and left ears of the dentists. The average hearing thresholds ranged from 10.23 dB to 20.15 dB in the right ear and 10.55 dB to 19.52 dB in the left ear across the tested frequencies. The highest thresholds were observed at 4000 Hz, with mean values of 20.15 dB in the right ear and 19.52 dB in the left ear. The lowest thresholds were at 250 Hz, with mean values of 10.23 dB for the right ear and 10.55 dB for the left ear.

An ANOVA test was applied to examine the hearing thresholds across normal frequencies, identifying significant differences in thresholds at various frequencies for both ears (P<0.001). Post-hoc analysis using Tukey's HSD test revealed significant differences between specific frequency pairs (P<0.001). Based on the mean values, the hearing threshold was highest at 4000 Hz and lowest at 250 Hz in both ears.

Table 1 - Distribution of the dentists (N=63) by their demographic and practice related factors

		N	%
Gender	Men	34	54
	Women	29	46
Age (year)	< 40	48	76
	≥ 40	15	24
Work experience (year)	≤ 5	13	21
	> 5	50	79
Working hours/day	≤ 4	12	19
	> 4	51	81

Table 2 - Mean hearing threshold of the dentists at normal frequencies in the right and left ear

	Right ear		Left ear	
Frequency	**Mean***	**SD**	**Mean***	**SD**
250	10.23	2.44	10.55	2.55
500	10.46	2.97	10.55	2.71
1000	11.34	4.59	11.26	4.66
2000	12.06	6.06	11.82	6.67
3000	14.60	9.08	15.00	7.88
4000	20.15	11.98	19.52	11.17
6000	17.93	8.87	19.12	6.92
8000	14.76	7.26	16.19	6.64

* Significant differences between frequency pairs for both ears (P<0.001) as evaluated by ANOVA and Tukey's HSD tests.

The dentists' mean hearing thresholds at high frequencies for both ears are presented in Table 3. At 10,000 Hz, the mean hearing threshold was 9.52 dB in the right ear and 11.66 dB in the left ear. As the frequency increased, so did the hearing thresholds, with the highest values observed at 16,000 Hz, where the mean threshold was 35.23 dB in the right ear and 33.09 dB in the left ear. The standard deviations were higher at the upper frequencies, indicating greater variability in hearing thresholds among the participants at these frequencies.

An ANOVA test was applied to examine the hearing thresholds across high frequencies, and identified significant differences in thresholds at various frequencies for both ears (P<0.001). Post-hoc analysis using Tukey's HSD test revealed significant differences between specific frequency pairs (P<0.001). The analysis showed that the mean hearing threshold was highest at 16000 Hz and lowest at 10000 Hz in both ears.

Table 3 - Mean hearing threshold of dentists at high frequencies in the right and left ear

	Right ear		Left ear	
Frequency	**Mean**	**SD**	**Mean**	**SD**
10000	9.52	3.67	11.66	5.95
12000	11.90	5.84	12.85	6.64
14000	24.04	13.34	24.42	10.64
16000	35.23	13.95	33.09	12.74

*Significant differences between frequency pairs for both ears (P<0.001), as evaluated by ANOVA and Tukey's HSD tests.

Table 4 outlines the distribution of hearing loss among the dentists at both normal and high frequencies in the right and left ears. At normal frequencies, hearing loss was most prevalent at 4000 Hz, affecting 34.9% of participants in the right ear and 33.3% in the left ear. Hearing loss at 6000 Hz was also notable, with 23.8% in the right ear and 31.7% in the left ear. No hearing loss was detected at 250 Hz in either ear. At high frequencies, the prevalence of hearing loss was more prevalent. The highest rates were observed at 16000 Hz, where 85.7% of participants had hearing loss in the right ear and 79.4% in the left ear. At 14000 Hz, hearing loss was present in 47.6% of right ears and 50.8% of left ears.

Table 4 - Distribution of hearing loss among the dentists (N=63) at normal and high frequencies in the right and left ear

		Right ear		Left ear	
		N	%	N	%
Normal frequencies	250	0	0	0	0
	500	1	1.6	0	0
	1000	4	6.3	4	6.3
	2000	5	7.9	5	7.9
	3000	8	12.7	10	15.9
	4000	22	34.9	21	33.3
	6000	15	23.8	20	31.7
	8000	14	22.2	15	23.8
High frequencies	10000	0	0	3	4.8
	12000	3	4.8	7	11.1
	14000	30	47.6	31	50.8
	16000	54	85.7	50	79.4

The distribution of hearing loss at various frequencies between male and female dentists is presented in Table 5. At normal frequencies (250–8000 Hz), hearing loss was generally more prevalent in men, especially at 4000 Hz, where a significant difference was observed in the right ear (p = 0.007), with 50% of men affected compared to 17.2% of women. No significant differences were found at most other normal frequencies. At high frequencies (10,000–16,000 Hz), the prevalence of hearing loss increased with frequency, with the highest rates observed at 16,000 Hz. Although men exhibited higher rates of hearing loss compared to women at 16,000 Hz, the differences were not statistically significant in either ear. Overall, men showed a slightly higher prevalence of hearing loss across most frequencies, but the differences were significant only at 4000 Hz in the right ear.

A direct correlation was observed between hearing thresholds and both work experience and age across all frequencies using Pearson's correlation coefficient. The relationship between work experience and hearing thresholds was statistically significant (p<0.001) at all frequencies in both ears, except for 250, 500, and 8000 Hz. Additionally, the relationship between age and hearing thresholds showed significance (p<0.001) at 4000, 12000, and 16000 Hz for the right ear, and at 16000 Hz for the left ear.

Table 5 - Distribution (%) of hearing loss among the dentists (N=63) at normal and high frequencies separately for men and women

Frequencies	Right ear		P-value*	Left ear		P-value*
	Men N (%)	Women N (%)		Men N (%)	Women N (%)	
250	0 (0)	0 (0)	--	0 (0)	0 (0)	--
500	0 (0)	1 (3.4)	0.275	0 (0)	0 (0)	--
1000	3 (8.8)	1 (3.4)	0.383	3 (8.8)	1 (3.4)	0.383
2000	4 (11.8)	1 (3.4)	0.224	4 (11.8)	1 (3.4)	0.224
3000	5 (14.7)	3 (10.3)	0.604	5 (14.7)	5 (17.2)	0.784
4000	17 (50)	5 (17.2)	0.007	14 (41.2)	7 (24.1)	0.153
6000	9 (26.5)	6 (20.7)	0.591	13 (38.2)	7 (24.1)	0.231
8000	9 (26.5)	5 (17.2)	0.38	9 (26.5)	6 (20.7)	0.591
10000	0 (0)	0 (0)	--	1 (2.9)	2 (6.9)	0.462
12000	3 (8.8)	0 (0)	0.101	6 (17.6)	1 (3.4)	0.074
14000	17 (50)	13 (44.8)	0.682	18 (56.2)	13 (44.8)	0.373
16000	31 (91.2)	23 (79.3)	0.180	29 (85.3)	21 (72.4)	0.208

* Statistical evaluation by the Chi-square and Fisher exact tests.

Discussion

The results of this study revealed significant findings concerning hearing thresholds among dentists, underscoring the occupational risk of noise-induced hearing loss in this profession. The mean age of participants was 36.2 years, with an average work experience of 8.6 years, indicating a relatively young and experienced cohort. Most of the affected dentists were men, and most had over five years of experience, with substantial daily exposure exceeding four hours, which aligned with previous studies emphasizing the prolonged exposure to dental equipment noise as a risk factor for hearing loss.[18, 19]

Hearing Thresholds at Normal and High Frequencies

The analysis of hearing thresholds at normal frequencies (250–8000 Hz) demonstrated that the highest thresholds occurred at 4000 Hz in both ears, a frequency that is commonly associated with the onset of NIHL.[20, 21] The mean thresholds ranged from 10.23 dB at 250 Hz to 20.15 dB at 4000 Hz in the right ear, and from 10.55 dB at 250 Hz to 19.52 dB at 4000 Hz in the left ear. These findings are consistent with those of previous studies, which also reported elevated thresholds at 4000 Hz, indicating potential early-stage hearing damage.[22]

At high frequencies (10,000–16,000 Hz), the hearing thresholds increased significantly, with the highest values observed at 16,000 Hz. The mean threshold at this frequency was 35.23 dB in the right ear and 33.09 dB in the left ear, which is considerably higher than at normal frequencies. This pattern is well-documented in literature, where extended high-frequency audiometry has been shown to be more sensitive in detecting early NIHL, particularly in individuals exposed to occupational noise.[4,23]

Prevalence of Hearing Loss

The prevalence of hearing loss among the dentists was notable, especially at 4000 Hz in the normal frequency range and at 16,000 Hz in the high frequency range. At 4000 Hz, hearing loss affected approximately 34.9% of participants in the right ear and 33.3% in the left ear, which is consistent with other studies that identified this frequency as particularly vulnerable to noise exposure in dental environments.[24] High frequency hearing loss was even more prevalent, with 85.7% of participants exhibiting hearing loss at 16,000 Hz in the right ear and 79.4% in the left ear. This supports the assertion that high-frequency audiometry is crucial for early detection of NIHL in high-risk occupations.[7, 9]

Gender Differences in Hearing Loss

The present study also identified gender differences in hearing loss, particularly at 4000 Hz, where men were significantly more affected than women in the right ear. This finding aligns with the results of other studies, which have suggested that men might be more susceptible to NIHL due to either greater noise exposure or inherent biological differences.[18] However, at high frequencies, while men exhibited higher rates of hearing loss, the differences were not statistically significant, suggesting that both male and female dentists are at similar risk levels for high-frequency hearing loss due to occupational noise.[19]

Correlation with Age and Work Experience

The study found a significant correlation between hearing thresholds and both age and work experience. As expected, older dentists and those with more years of practice exhibited higher hearing thresholds, particularly at 4000, 12000, and 16000 Hz. This relationship is well-documented in the literature, where age-related hearing loss and cumulative noise exposure over time contribute to increased hearing thresholds.[25] The significant correlation at higher frequencies further underscores the importance of early screening and intervention for dentists to prevent long-term auditory damage.[22]

This study had several limitations that should be considered when interpreting the findings. First, the study's cross-sectional design limited the ability to establish causality between occupational noise exposure and hearing loss among dentists. The use of a convenient sample of 63 dentists from a single city (Yazd, Iran) may limit the generalizability of the results to other populations, particularly in different geographic regions or with varying noise exposure levels. The reliance on self-reported data for factors such as noise exposure outside the work environment and use of hearing protection devices introduced the potential for recall bias. Furthermore, while the study controlled for several confounding variables, there may be other unmeasured factors, such as genetic predispositions or specific workplace practices, that could influence hearing loss outcomes. Additionally, the small sample size of 63 participants may reduce the statistical power of the study, particularly in subgroup analyses. Lastly, the study's data collection occurred within a limited time frame (June to July 2014), thus, it does not account for potential seasonal variations in noise exposure or changes in workplace practices over time. However, the findings provide valuable preliminary insights into the auditory health of dentists exposed to occupational noise, highlighting the need for larger, multi-center studies to confirm these results.

Conclusion

This study provided significant insights into the auditory health of dentists, highlighting the prevalence of hearing loss and its correlation with age, work experience, and exposure to occupational noise. The findings revealed that dentists are at considerable risk of NIHL.

Hearing thresholds indicated early signs of NIHL among the participants. Additionally, the study found that hearing loss was more prevalent among male dentists. The correlations between hearing thresholds and both age and work experience further underscored the cumulative impact of prolonged exposure to dental noise. The significant relationships found at key frequencies suggested that as dentists age and gain more experience, their risk for hearing impairment increases, particularly at higher frequencies. Overall, these findings emphasized the need for proactive measures, including regular hearing assessments and the implementation of noise-reduction strategies, to protect the auditory health of dental professionals. Further research is recommended to explore long-term effects and to develop targeted interventions to mitigate the risk of NIHL in this population.

Acknowledgement: We wish to thank all participating dentists for their cooperation.

Author Contributions: H.G.: Conceptualization, Methodology, Investigation, Writing – Original Draft, Supervision; and S.J. M.M.: Conceptualization, Methodology, Review & editing, Supervision; and A.E.: Visualization, Methodology, Review & editing, Supervision; and A.T.: Methodology, Project implementation, Data Curation.

Funding: No funding was received for this research.

Ethical Approval Code: At the time of performing this study, having an ethical approval code was not mandatory. However, dentists were informed that participation in the study was entirely voluntary. They were given details about the study's objectives, and questionnaires were distributed only to those who provided their consent. Participants were also assured that their responses would be kept confidential. The study received approval from the Department of Community Oral Health at Shahid Beheshti School of Dentistry.

Informed Consent Statement: Questionnaires were distributed only to those who provided their written informed consent.

Data Availability Statement: The datasets generated during the current study are available from the corresponding author upon reasonable request.

Using AI: This manuscript has benefited from the use of Deepseek (version 3) exclusively for language improvement. Deepseek was utilized to enhance the clarity, coherence, and grammatical accuracy of the text while ensuring that the original meaning and scholarly integrity of the content remained unchanged. No part of the research design, data analysis, interpretation of results, or conceptual contributions were generated or influenced by AI. The authors take full responsibility for the intellectual content of this work.

Conflict of Interest: No conflicts of interest to declare.

References

1. Chen KH, Su SB, Chen KT. An overview of occupational noise-induced hearing loss among workers: epidemiology, pathogenesis, and preventive measures. Environ Health Prev Med. 2020;25(1):65. doi: 10.1186/s12199-020-00906-0

2. Alberti G, Portelli D, Galletti C. Healthcare professionals and noise-generating tools: challenging assumptions about hearing loss risk. International Journal of Environmental Research and Public Health. 2023 Aug 4;20(15):6520. doi: 10.3390/ijerph20156520

3. Hoth S, Baljić I. Current audiological diagnostics. GMS Curr Top Otorhinolaryngol Head Neck Surg. 2017;16:Doc09. doi: 10.3205/cto000148

4. Mehrparvar AH, Mirmohammadi SJ, Ghoreyshi A, Mollasadeghi A, Loukzadeh Z. High-frequency audiometry: a means for early diagnosis of noise-induced hearing loss. Noise Health. 2011;13(55):402-6. doi: 10.4103/1463-1741.90295

5. Mojarad F, Massum T, Samavat H. Noise levels in dental offices and laboratories in Hamedan, Iran. J Dent (Tehran). 2009;6(4):181-6.

6. Kurabi A, Keithley EM, Housley GD, Ryan AF, Wong AC-Y. Cellular mechanisms of noise-induced hearing loss. Hear Res. 2017;349:129-37. doi: 10.1016/j.heares.2016.11.013

7. Soltanzadeh A, Ebrahimi H, Fallahi M, Kamalinia M, Ghassemi S, Golmohammadi R. Noise induced hearing loss in Iran:(1997–2012): systematic review article. Iran J Public Health. 2014;43(12):1605-15.

8. Kadanakuppe S, Bhat PK, Jyothi C, Ramegowda C. Assessment of noise levels of the equipments used in the dental teaching institution, Bangalore. Indian J Dent Res. 2011;22(3):424-31. doi: https://doi.org/10.4103/0970-9290.87065

9. Fazli M, Nassiri P, Hasani Z. Noise induced hearing loss in Zanjan dentists. J Adv Med Biomed Res. 2009;17(68):65-74. doi:

10. Škerková M, Kovalová M, Mrázková E. High-frequency audiometry for early detection of hearing loss: a narrative review. Int J Environ Res Public Health. 2021;18(9):4702. doi: 10.3390/ijerph18094702

11. Singh R, Saxena R, Varshney S. Early detection of noise induced hearing loss by using ultra high frequency audiometry. Int. J. Otolaryngol. 2009;10(2):1-5.

12. Ahmed HO, Dennis JH, Badran O, Ismail M, Ballal SG, Ashoor A, et al. High-frequency (10–18 kHz) hearing thresholds: reliability, and effects of age and occupational noise exposure. Occup Med (Lond). 2001;51(4):245-58. doi: 10.1093/occmed/51.4.245

13. Maccà I, Scapellato ML, Carrieri M, Maso S, Trevisan A, Bartolucci GB. High-frequency hearing thresholds: effects of age, occupational ultrasound and noise exposure. Int Arch Occup Environ Health. 2015;88(2):197-211. doi: 10.1007/s00420-014-0951-8

14. Khaimook W, Suksamae P, Choosong T, Chayarpham S, Tantisarasart R. The prevalence of noise-induced occupational hearing loss in dentistry personnel. Workplace Health Saf. 2014;62(9):357-60. doi: 10.3928/21650799-20140815-02

15. Lesaffre E, Feine J, Leroux B, Declerck D. Statistical and methodological aspects of oral health research: Wiley Online Library; 2009. doi: 10.1002/9780470744116

16. Association AS-L-H. Guidelines for manual pure-tone threshold audiometry. 2005. Link: (Accessed on 2025 July 21) https://www.asha.org/policy/gl2005-00014/?srsltid=AfmBOoqgRQqEDbeYlxFHSnfP32uiDdwUJa-2d2jz0tEU2HflVyo9jc9l

17. Humes LE. The world health organization's hearing-impairment grading system: an evaluation for unaided communication in age-related hearing loss. Int J Audiol. 2019;58(1):12-20. doi: 10.1080/14992027.2018.1518598

18. Alabdulwahhab BM, Alduraiby RI, Ahmed MA, Albatli LI, Alhumain MS, Softah NA, et al. Hearing loss and its association with occupational noise exposure among Saudi dentists: a cross-sectional study. BDJ open. 2016;2:16006. doi: 10.1038/bdjopen.2016.6

19. Al-Rawi NH, Al Nuaimi AS, Sadiqi A, Azaiah E, Ezzeddine D, Ghunaim Q, et al. Occupational noise-induced hearing loss among dental professionals. Quintessence Int. 2019;50(3):245-50. doi: 10.3290/j.qi.a41907

20. Lopes AC, de Melo ADP, Santos CC. A study of the high-frequency hearing thresholds of dentistry professionals. Int Arch Otorhinolaryngol. 2012;16(2):226-31. doi: 10.7162/s1809-97772012000200012

21. Messano GA, Petti S. General dental practitioners and hearing impairment. J Dent. 2012;40(10):821-8. doi: 10.1016/j.jdent.2012.06.006

22. Gonçalves CG, Santos L, Lobato D, Ribas A, Lacerda AB, Marques J. Characterization of hearing thresholds from 500 to 16,000 hz in dentists: a comparative study. Int Arch Otorhinolaryngol. 2015;19(2):156-60. doi: 10.1055/s-0034-1390138

23. Shetty R, Shoukath S, Shetty SK, Dandekeri S, Shetty NHG, Ragher M. Hearing assessment of dental personnel: a cross-sectional exploratory study. J Pharm Bioallied Sci. 2020;12(Suppl 1):S488-94. doi: 10.4103/jpbs.jpbs_145_20

24. Abrisham SM, Shafiee M, Abediny Sanich M. Evaluation of hearing status in employees of dental prosthodontics laboratories in Yazd. J. Toloo Behdasht. 2020;19(3):62-72. doi:10.18502/tbj.v19i3.4172

25. Ehsani M, Monadi M, Ranjbar S, Bijani A, Ghasemi N. Hearing threshold evaluation of dentists in Babol (north of Iran). Caspian Journal of Dental Research. 2014;3(1):14-20. doi: 10.22088/cjdr.3.1.14