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ISSN: 1641-9251

e-ISSN: 2081-3252

Audiological Profile of Fishermen Using Fiber Motor Boats in Puducherry

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DOI: 10.5603/imh.101888

Article type: Original article

Submitted: 2024-08-02

Accepted: 2024-12-27

Published online: 2025-03-05

ABSTRACT

Background: Fishermen face multiple occupational health risks including drowning, traumatic injuries, asphyxia, and skin allergies. Additionally, their exposure to high intensities of engine noise during fishing puts them at risk of Noise-Induced Hearing Loss (NIHL). Inadequate use of ear protective devices and lack of awareness further contribute to the prevalence of NIHL among fishermen. The study aims to measure the engine noise level of Fiber motor boats and develop an Audiological profile of fishermen in Puducherry.

Methods: Thirty fishermen between the ages of 20 to 45 years, who operate fiber motor boats were tested using Pure-Tone and speech audiometry, High-Frequency Audiometry, Immittance audiometry, Single and Multifrequency tympanometry, and Distortion Product Oto-Acoustic Emissions (DPOAEs). Additionally, the engine noise level of fiber motor boats was measured using a Sound Level Meter.

Results: The engine noise levels ranged from 92dB(A) to 115dB(A) and 81dB(A) to 106dB(A) at 3 feet and 6 feet distance respectively, which exceeds the permissible 90dB(A) limit in accordance to OSHA standards for 8 hours. Audiological test results indicated hearing loss primarily at 4kHz and at higher frequencies. Single and Multifrequency tympanometry results were atypical. Although PTA at standard frequencies was normal, DPOAEs were affected.

Conclusion: It is crucial to educate fishermen about ear care and using ear protection to prevent hearing loss due to harmful noise levels. In addition, the importance of using High-Frequency audiometry and OAE’s for early detection of NIHL is emphasized.

Keywords: Audiological profiling, Fishermen, Occupational hearing loss, Noise Induced Hearing Loss.

INTRODUCTION

Indian fishermen form a vital socioeconomic backbone, contributing to the country's food security and coastal livelihoods. Fishermen are disproportionately exposed to a spectrum of occupational health hazards, encompassing drowning, traumatic injuries tied to their work, asphyxiation, skin allergies, and even a complicated susceptibility to certain cancers including gastric, skin, and oesophageal malignancies [1,2]. Occupational hearing loss among fishermen is a prevalent and concerning issue worldwide, as they are consistently being exposed to loud and continuous noises, such as engine noise from boat engines, generators, winches, and other machinery, as well as the natural noise of wind, waves, and ocean currents. The constant roar of engines and other machinery generates high noise levels leading to damage in hearing over time. Prolonged exposure to loud noise damages the delicate hair cells in the inner ear, leading to permanent hearing loss. This condition typically affects high-frequency hearing first and can progress to affect speech understanding. Fishermen do not consistently use or have access to proper hearing protection devices. This can exacerbate the risk of hearing loss [3].

The prevalence of occupational hearing loss among fish harvesters worldwide was 6% to 80% [1]. In the Indonesian fishermen group, Tasik et al. [4] have reported hearing loss prevalence rate of 68.18% in fishermen above the age of 40 years. Further, they also reported a higher incidence of middle ear problems due to their frequent involvement in diving during fishing. Concerning the degree of hearing loss, Anwar et al. [5] found the prevalence of hearing loss in fishermen to be 97.50%, among which 52.50% had mild hearing loss, 43.75% had moderate hearing loss and 1.25% had moderately severe hearing loss. In addition, the degree of hearing loss increased with an increase in years of experience, intensity of noise, and duration of exposure. Therefore, based on the above literature, although the prevalence of hearing loss among fishermen is well documented, they are underserved when it comes to hearing loss prevention as well as being covered under various other health programs [6].

The type of boat and type of engine used in boats for fishing varies across regions all over the world. Each engine emits different noise levels ranging from 85 dBA to 105 dBA. Sinworn and Viriyawattana [7] reported the noise level emitted from long tail boat engine to be >85dBA in the frequency range of 2000 to 8000Hz. Results of a study by Vinezzia [8] found the noise emitting from boat engines and compressor engines to be around 99.7dBA while data by Paini et al. [9] reported noise levels in a 9 horsepower (HP) engine boat to be around 86 to 105dBA The above findings have been documented for the fishermen communities outside India.

Prior studies that reported hearing loss in Indian fishermen were carried out using questionnaires and Pure Tone Audiometry (PTA) findings [10]. Although PTA is the primary hearing assessment in occupational hearing programs, recent studies have emphasized the importance of incorporating OAEs and High-Frequency Audiometry. These additional tests hold the potential to detect early signs of hearing loss and offer preventive measures, especially for individuals who exhibit normal outcomes in conventional PTA assessments [11,12]. Immittance audiometry provides information on the middle ear status of fishermen as they perform activities such as swimming and diving which might have an impact on compliance of tympanic membrane, middle ear pressure, and hearing. This holistic approach is imperative in addressing the unique challenges faced by Indian fishermen and ensuring the preservation of their auditory well-being. Therefore, the present study aims to assess the noise level of fiber motor boats and create a profile of Audiological test results for fishermen in the Puducherry region of India.

MATERIAL AND METHODS

A total of 30 Fishermen between the age range of 20 to 45 years (27.1± 9.67) who use fiber motor boats for fishing in Puducherry (India) were selected for the study purpose using convenience sampling. The Fisherman had a minimum of 2 years (10.1 ± 9.31) of fishing experience. Participants with a history or complaints of any middle ear pathology, Otological Surgery, Psychological factors, Neurological condition, and usage of ototoxic medications were excluded from the study. The purpose of the study was explained to all the participants and written informed consent was obtained from them. The study adhered to the institutional ethical guidelines (Reference Number: VMCN PDY/IEC 2023/143). Engine noise levels of the fiber motor boats were measured using a Sound Level Meter (SLM) and the Audiological profile of Indian fishermen was analyzed using a combination of behavioral and physiological auditory tests such as Pure-Tone Audiometry, High-Frequency Audiometry, Speech audiometry, Immitance audiometry, Multifrequency tympanometry, and Distortion Product Oto Acoustic Emissions.

Measurement of Engine noise levels in the Fiber motor boats

SLM type 1 (Lutron SL4001) was calibrated before the noise measurements. The Noise level from the motor boats was measured from the reference point which means the SLM was placed at 3 feet and 6 feet distance from the engine and at one-meter height from the engine, for 30 minutes with 'A' time weighting average in slow mode. Noise levels were measured in five fiber motor boats from various regions across Puducherry.

Audiological profiling

A detailed case history was taken from all the participants, consisting of demographic data, any history or complaints related to hearing, vestibular, and neurological problems. In addition, questions related to fishermen's occupation were asked, which included type of boat, type of engine used for fishing, fishing experience, duration of fishing and duration of the diving. An otoscopic examination was done to rule out any pathology in the external ear and tympanic membrane. All the Physiological and behavioral tests were conducted in a sound-treated room with an ambient noise level well within the acceptable level for audiometric room (ANSI S3.1, 1999) standards [13].

A calibrated Interacoustics AC40 Audiometer was used to evaluate Pure tone thresholds from 250Hz to 8kHz for air conduction, 250Hz to 4kHz for bone conduction, and High-frequency air conduction threshold from 9kHz to 20 kHz using modified Hugson-Westlake procedure [14]. Pure tone average was calculated as the average of thresholds at 500Hz, 1kHz, 2kHz, and 4kHz. Speech performance was assessed using Speech Recognition

Threshold (SRT) and Speech Identification Scores (SIS). SRT was performed at 20dB sensation level (SL) above the pure tone average using spondee words in Tamil [15] and SIS was done at SRT + 40dB using phonetically balanced (PB) words in Tamil [16]. Calibrated Interacoustics Titan immittance audiometer was used for the measurement of single frequency tympanometry (226 Hz probe tone) and Multifrequency tympanometry to find out the resonance frequency of the middle ear for frequencies from 200-2000Hz. The ear canal volume, Compliance, Peak pressure, Gradient, and Resonance frequency (RESFREQ) of the middle ear were measured. To study the function of the Outer Hair cells, Neurosoft Neuro Audio.Net (version 2010) Distortion Product Oto-acoustic Emissions (DPOAE) was used. DPOAEs were recorded for 1000Hz to 12000Hz using L1=65, and L2=55 with F2\F1 ratio of 1.22.

RESULTS AND DISCUSSION

Noise measurement

The measured minimum to maximum noise level was 92 dB(A) to 115 dB(A) and 81 dB(A) to 106 dB(A) at 3 feet and 6 feet distance from the engine respectively. All the five fiber motor boats' engine noise level measured were >90 dB(A), which is greater than the permissible noise level for 8 hours as described by the Ministry of Labour, Model Rules under Factories Act (1948), Government of India. Similar results were noted in the studies conducted by Panini et al. [9] where they found that engine noise levels of motor boats ranged from 80 to 105 dB (A). Levin et al. [17] reported engine noise levels between 94.8 to 105.0 dB(A) and Anwar et al. [5] recorded engine noise levels within the range of 98.9 dB to 101 dB(A).

Audiological Profiling

Statistical analysis was carried out by using Statistical Package for the Social Sciences (SPSS) version 29. Descriptive statistics such as Mean, Standard Deviation, Median, and Interquartile range (IQR) were calculated. Normality of the data was assessed using Kolmogorov Smirnov's test. Results showed non-normal distribution hence non-parametric tests were used for further analysis. Wilcoxon Signed rank was used to compare right and left ear for all the audiological tests. $p<0.05$ was considered statistically significant for all the analyses.

Results of Pure-Tone Audiometry and Extended High Frequency Audiometry

On analyzing the stimulus-response paradigm of participants at various frequencies, majority of the participants demonstrated a complete response rate of 100% across the frequency spectrum ranging from 250 Hz to 10,000 Hz. In the extended higher frequency range, spanning from 11.2 kHz to 16 kHz, response percentages exhibited variability, ranging from 98.3% to 43.3%. Additionally, 18 kHz and 20 kHz were excluded from the statistical analysis due to reduced response rates of 3.33% and complete absence of responses, respectively. Furthermore, it was noticed that the percentage of responses decreases as the frequency increases.

Table 1 represents PTA and Extended High-Frequency thresholds. Elevated hearing thresholds (>15dBHL) were notably present within the frequency range of 3000 Hz to 6000 Hz, with a particular emphasis on 4000 Hz. Conversely, in high-frequency audiometry, lower thresholds were observed between 8000 Hz and 11200 Hz, registering below the 15 dB level, while elevated thresholds were recorded from 12500 Hz to 16000 Hz, exceeding the normative threshold. Intriguingly, even though these frequency thresholds exceeded the standard limits, participants did not indicate any perceived hearing difficulties. This underscores the complexity of the relationship between measured hearing thresholds and the subjective experience of hearing impairment. Wilcoxon Signed Ranks Test was conducted to examine potential differences of PTA and Extended high-frequency thresholds between the right and left ears. The results indicated that there was no statistically significant variation observed between the two ears in any of the frequencies. Kirchner et al. [18] found results consistent with the notion that the effectiveness of auditory perception is higher within the 3kHz to 6kHz frequency range compared to the lower frequencies of 0.5kHz to 2kHz. Suter [19] highlighted a pattern in audiograms wherein the hearing sensitivity begins to decline after the lower frequencies, forming a V-shaped curve with a dip typically occurring at 4kHz or 6kHz. Similar findings were obtained by Sharif et al. [20] in traffic policemen and Ranga et al. [21] in industrial workers who are exposed to noise. Panini et al. [9] reported that both PTA and high-frequency reports of fishermen indicated 82% of high-frequency hearing loss. Collectively, these studies emphasize the significance of the 3kHz to 6kHz range in auditory perception and highlight the vulnerability of hearing thresholds, particularly at frequencies such as 4kHz and 6kHz, in various occupational groups.

To estimate the degree of hearing loss, Pure Tone average was calculated for 500Hz, 1000Hz, and 2000Hz. Among 30 participants (n=60 ears), 45% (n=27) had normal hearing, 46.7% (n=28) had Minimal hearing loss and 8.3% (n=5) had Mild hearing loss. Among these, Unilateral hearing loss was reported in one individual who had significant Mild hearing loss in the left ear only. In contrast, a study by Levin et al. [17] reported that 30.5% of the participants experienced Mild hearing loss, 18.8% had Moderate hearing loss, 8.1% faced Moderately severe hearing loss, 1.5% encountered severe hearing loss, and 0.5% dealt with profound hearing loss. Findings from the data of Anwar et al. [5] revealed that 2.50% exhibited normal hearing, 52.50% had Mild hearing loss, 43.73% showed Moderate hearing loss, and 1.25% experienced Moderately Severe hearing loss.

Results of Speech Audiometry

Speech audiometry scores were assessed using measurements derived from SRT and SIS. The findings revealed that there was no decrement in speech audiometry scores among the participants, with the SRT correlating with the PTA (Median=20; IQR=10) and perfect 100% Speech Identification Score. Wilcoxon signed-rank test revealed no statistically significant difference ($p>0.05$) in comparison of SRT and SIS between the right and left ear respectively. On the contrary, Liberman et al. [22] highlighted that NIHL can be linked to lower scores in speech discrimination tests, both in quiet and background noise. Therefore, to ensure the most accurate assessment of NIHL, it is recommended to include speech recognition tests conducted in quiet and noisy backgrounds, in addition to evaluating pure tone thresholds. This approach is advocated for a comprehensive understanding of the impact of hearing loss on speech perception, particularly in situations involving background noise.

Results of Single frequency tympanometry and Multi frequency tympanometry

The outcomes of the Single frequency tympanometry analysis are represented in Table 2. Results indicated that the median values of Compliance, Ear Canal Volume, Peak Pressure, and Gradient were well within the established normal range. The normative range considered in the study was 0.5 to 1.75 ml for static compliance, 0.8 to 2 ml for ear canal volume, peak pressure +50 to -100dapa, and Gradient 50 to 110dapa [23].

Out of the total of 60 ears examined, 68.35% (n=41 ears) exhibited a "Type A" tympanogram and 31.65% (n=19 ears) displayed an "As" type tympanogram, implying a compliance measurement below 0.5 ml. Additionally, the results of the Multi-frequency tympanometry (Resonance Frequency) measurements were also within the expected normal range, consistent with previous literature reports 800–1100 Hz [24], 935.1±344.4 Hz [25] and 907±198 Hz [26]. But the median of compliance and Resonance Frequency lay in the lower border of normative range which might represent a mass-dominant middle ear in fishermen. Additionally, when comparing the right and left ears using Wilcoxon signed-rank test, no significant variations were observed. This implies that the measurements and responses between the two ears were consistent and did not display any noteworthy differences.

Results of Oto Acoustic Emission

Distortion Product Otoacoustic emission with a frequency range between 1 kHz to 12 kHz was measured for the entire participants. Analysis of DPOAE revealed better Signal-to-Noise Ratio (SNR) within the frequency range of 1000 Hz to 2000 Hz, 5000 Hz, and 8000 Hz (Table 3). Conversely, diminished SNR was observed at the remaining frequencies, especially at 2500Hz to 4000Hz, 6400Hz, and higher frequencies above 8000 Hz. This pattern of results aligns with findings of Mehrparvar et al. [27], wherein they observed similar findings in Industrial workers from the tile and ceramic sector. Their study highlighted that high frequencies in DPOAE were more adversely affected than low frequencies. Similarly, Panini et al. [9] noted poorer DPOAE outcomes within a fisherman population affected by NIHL. Additionally, Zeena [28] reported a correlation between absent or significantly reduced DPOAE amplitude and SNR, which was linked to the duration of noise exposure. On comparison of DPOAE between the right and left ear using Wilcoxon signed-rank test, a statistically significant difference was noted only at 4 kHz. The results of DPOAEs correlate with the results of pure tone and extended high frequency responses. These outcomes were consistent with prior research, emphasizing the impact of noise exposure on DPOAE.

The study has been carried out on a smaller sample in the Puducherry region of India. Hence there is a need to carry out similar studies in different regions across India using a larger sample size to account for diversity in the type of fishing boats used.

CONCLUSION

The study indicated that the noise levels experienced by the fishermen were higher than what is considered safe as per standardized guidelines. Being in a noisy environment had a negative impact on the participant’s hearing, communication, and sound localization abilities. Therefore, it's important for Audiologist’s to sensitize fishermen about the dangers of engine noise on their hearing and the significance of using ear protective devices. The Majority of the fishermen had normal hearing sensitivity in routine audiometric frequencies (250Hz, 500Hz, 1kHz, 2kHz, 4kHz, & 8kHz). As a result, it is important to add extended high-frequency audiometry and OAEs as part of the test battery for early detection of noise-induced hearing problems. Additionally, the information gained from the findings suggests counselling regarding ear care and hygiene as well as regular monitoring of hearing to address noise-related hearing issues as early as possible.

REFERENCES

1. Yadav OP, Sarkar A, Shan D, Rahman A, Moro L. Occupational noise exposure and health impacts among fish harvesters: a systematic review. Int Marit Health. 2021;72(3):199-205. doi: 10.5603/IMH.2021.0038. PMID: 34604990.
2. C.Seethalakshmi and Dr.Karaline Karunagari. Occupational health problems of the fishermen residing in selected villages at cuddalore district. Int J Creat Res Thoughts [Internet]. 2022;10(1):d71–6. Available from: http://ijcrt.org/viewfull.php?&p_id=IJCRT2201339
3. Ernawati M. Literature Review: Risk Factors Affecting Hearing Loss among Fishermen in Indonesia. J Drug Deliv Ther. 2021 May 15;11:153–9. doi:10.22270/JDDT.V11I3.4780
4. Tasik YI. Analisis Hubungan Tingkat Kebisingan terhadap Penurunan Ambang Dengar (Hearing Loss) pada Nelayan Kelurahan Pontap Kota Palopo Provinsi Sulawesi Selatan Tahun 2016 [Analysis of the Relationship between Noise Levels and Hearing Loss in Fishermen in Pontap Village, Palopo City, South Sulawesi Province in 2016]. J Kesehat Mega Buana. 2018; 4(1):1-9. Available from: https://osf.io/gyejz/download
5. Anwar M, Savitri E, Dyah T. Audiometric Profile of Fishermen Using Motor Boat in Barombong Village, Makassar. Indian J Public Heal Res Dev. 2019;10(10). doi:10.5958/0976-5506.2019.03055.9
6. Rapisarda V, Valentino M, Bolognini S, Fenga C. Il rischio rumore a bordo dei pescherecci: alcune considerazioni sulla prevenzione e protezione degli esposti [Noise-related occupational risk aboard fishing vessels: considerations on prevention and the protection of exposed workers]. G Ital Med Lav Ergon. 2004 Jul-Sep;26(3):191-6. Italian. PMID: 15551949.
7. Sinworn S, Viriyawattana N. Effect of small boat engine noise on hearing loss of fishermen and efficiency of small boat engine silencer. Glob J Environ Sci Manag [Internet]. 2024;10(3):1297–712. https://doi.org/10.22034/gjesm.2024.03.21
8. Vinezzia D. Identifikasi Bahaya Keselamatan dan Kesehatan Kerja Pada Aktivitas Nelayan [Identification of Occupational Safety and Health Hazards in Fishermen's Activities]. J Penelit Perawat Prof. 2021 Jan 31;3:117–26. https://doi.org/10.37287/jppp.v3i1.345
9. Paini MC, Morata TC, Corteletti LJ, Albizu E, Marques JM, Santos L. Audiological findings among workers from Brazilian small-scale fisheries. Ear Hear. 2009 Feb;30(1):8-15. doi: 10.1097/AUD.0b013e31818fba17. PMID: 19050644.
10. Arumugam I, Tukalan G, Anchery VA, Khosh A. Evaluation of noise induced hearing

loss in fishermen who work in motor boats in Karaikal. J Evol Med Dent Sci. 2015;4(73):12645–51. DOI:10.14260/JEMDS/2015/1823

11. Avan P, Bonfils P. Distortion-product otoacoustic emission spectra and high-resolution audiometry in noise-induced hearing loss. Hear Res. 2005;209(1):68–75. https://doi.org/10.1016/j.heares.2005.06.008

12. Kemp DT. Otoacoustic emissions, their origin in cochlear function, and use. Br Med Bull. 2002;63:223-41. doi: 10.1093/bmb/63.1.223. PMID: 12324396.

13. Frank T. ANSI update: maximum permissible ambient noise levels for audiometric test rooms. Am J Audiol. 2000 Jun;9(1):3-8. doi: 10.1044/1059-0889(2000/003). PMID: 10943020.

14. Carhart R, Jerger JF. Preferred Method For Clinical Determination Of Pure-Tone Thresholds. J Speech Hear Disord [Internet]. 1959 Nov 1;24(4):330–45. Available from: https://doi.org/10.1044/jshd.2404.330

15. Boominathan P. Picture speech identification test for children in Tamil [master's dissertation]. Mysore: University of Mysore; 1999.

16. Samuel JD. Development and standardization of phonetically balanced test materials in Tamil language [master's dissertation]. Mysore: University of Mysore; 1976.

17. Levin JL, Curry WF 3rd, Shepherd S, Nalbone JT, Nonnenmann MW. Hearing Loss and Noise Exposure Among Commercial Fishermen in the Gulf Coast. J Occup Environ Med. 2016 Mar;58(3):306-13. doi: 10.1097/JOM.0000000000000642. PMID: 26949882.

18. Kirchner DB, Evenson E, Dobie RA, Rabinowitz P, Crawford J, Kopke R, et al. Occupational Noise-Induced Hearing Loss: ACOEM Task Force on Occupational Hearing Loss. J Occup Environ Med. 2012 Jan;54(1):106–8. DOI: 10.1097/JOM.0b013e318242677d

19. Suter AH. Construction noise: exposure, effects, and the potential for remediation; a review and analysis. AIHA J (Fairfax, Va). 2002 Nov-Dec;63(6):768-89. doi: 10.1080/15428110208984768. PMID: 12570087.

20. Sharif A, Taous A, Siddique BH, Dutta PG. Prevalence of noise induced hearing loss among traffic police in Dhaka Metropolitan City. Mymensingh Med J. 2009 Jan;18(1 Suppl):S24-28. PMID: 19377427.

21. Ranga RK, Yadav SPS, Yadav A, Yadav N, Ranga SB. Prevalence of occupational noise induced hearing loss in industrial workers. Indian J Otol. 2014;20(3):115–8. DOI: 10.4103/0971-7749.136848

22. Liberman MC, Epstein MJ, Cleveland SS, Wang H, Maison SF. Toward a Differential Diagnosis of Hidden Hearing Loss in Humans. PLoS One. 2016 Sep 12;11(9):e0162726. doi: 10.1371/journal.pone.0162726. PMID: 27618300; PMCID: PMC5019483.
23. Gelfand SA. Essentials of Audiology 4th ed. New York: Thieme; 2016.
24. Özgür A, Müjdeci B, Terzi S, Özergin Coşkun Z, Yiğit E, Dursun E. Wideband Tympanometry Normative Data for Different Age Groups in Turkish Population. J Int Adv Otol. 2016 Apr;12(1):82-6. doi: 10.5152/iao.2015.1408. PMID: 27340989.
25. Demir E, Afacan NN, Celiker M, Celiker FB, İnecikli MF, Terzi S, Dursun E. Can Wideband Tympanometry Be Used as a Screening Test for Superior Semicircular Canal Dehiscence? Clin Exp Otorhinolaryngol. 2019 Aug;12(3):249-254. doi: 10.21053/ceo.2018.01137. Epub 2018 Nov 22. PMID: 30458602; PMCID: PMC6635713.
26. Śliwa L, Kochanek K, Jedrzejczak WW, Mrugała K, Skarżyński H. Measurement of Wideband Absorbance as a Test for Otosclerosis. J Clin Med. 2020 Jun 18;9(6):1908. doi: 10.3390/jcm9061908. PMID: 32570989; PMCID: PMC7355593.
27. Mehrparvar AH, Mirmohammadi SJ, Davari MH, Mostaghaci M, Mollasadeghi A, Bahaloo M, et al. Conventional Audiometry, Extended High-Frequency Audiometry, and DPOAE for Early Diagnosis of NIHL. Iran Red Crescent Med J. 2014 Jan;16(1):e9628. doi: 10.5812/ircmj.9628. Epub 2014 Jan 5. PMID: 24719719; PMCID: PMC3964437.
28. Zeena VP. Cochlear and neural functions in industrial workers exposed to occupational noise [master's dissertation]. Mysore: University of Mysore; 2015.

TABLES

Table 1. Representation of median, IQR of Pure-tone audiometry and Extended High frequency audiometry and its comparison between right and left ear

PTA & EHF Frequency (Hz)	**Right ear**		**Left ear**		***p*- value**
	Median	**IQR**	**Median**	**IQR**	
250	15.00	8.75	15.00	8.75	.952
500	15.00	5	15.00	5	.973
1000	15.00	5	15.00	5	.396
2000	17.50	5	15.00	8.75	.460
3000	20.00	12.5	20.00	15	.290
4000	20.00	20	25.00	15	.822
6000	20.00	11.5	20.00	10	.663
8000	15.00	11.25	17.50	20	.770
9000	15.00	10	15.00	15	.526
10000	15.00	11.25	15.00	17.5	.587
11200	15.00	10	17.50	21.25	.924
12500	20.00	27.5	20.00	25	.518
14000	32.50	23.75	25.00	15	.778
16000	32.50	15	27.50	30	.068

Note**.** PTA = Pure Tone Audiometry; EHF = Extended High frequency Audiometry; IQR = Inter Quartile Range.

Table 2. Representation of median, IQR of Single frequency tympanometry, Multi frequency tympanometry parameters and its comparison between right and left ear

Variable	**Right ear**		**Left ear**		***p*-value**
	Median	**IQR**	**Median**	**IQR**	
Compliance	0.50	0.38	0.66	0.47	.080
Ear canal volume	1.42	0.35	1.38	0.55	.959
Peak pressure	-9.00	16.25	-10.50	22.5	.253
Gradient	111.50	50	99.50	40	.181
Resonance frequency	756.50	316.25	727.00	253.5	.812

Note. IQR = Inter Quartile Range.

Table 3. Representation of median and IQR of Distortion Product Oto acoustic emission and its comparison between right and left ear

DPOAE	Right ear		Left ear		*p*- value
Frequency (Hz)	Median	IQR	Median	IQR	
1000	6.30	0.7	6.25	5.42	.124
1250	6.30	0.6	6.25	2.18	.133
1600	6.30	0.62	6.20	0.77	.318
2000	6.10	2.53	6.10	5.8	.387
2500	1.55	11.41	1.35	11.65	.567
3200	2.00	11.38	-0.55	9.63	.388
4000	3.90	7.55	5.70	4.45	.011*
5000	6.20	0.97	6.10	6.4	.365
6400	2.75	7.83	3.60	6.63	.510
8000	6.10	3.6	6.10	7.43	.127
8889	3.10	10.53	5.50	8.2	.069
10000	0.50	9.98	0.80	12.33	.781
11429	-3.75	6.08	-5.50	10.77	.217

Note. DPOAE = Distortion Product Oto Acoustic Emission; IQR = Inter Quartile Range.

*$p<0.05$