Original Article

Prevalence of Noise-Induced Hearing Loss in Sulaymaniyah Governorate

Mariwan Latif Fatah, Blnd Dler Bahjat [*], Mazer Bakr Saeed, Mohammed Rebwar Omer
Department of Medical Sciences, College of Medicine, University of Sulaimani, Sulaimani 46001, Kurdistan Region, Iraq.
[*] Corresponding author: **Nihlprevalence@gmail.com**

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Abstract

Background: Noise exposure is a common and preventable cause of hearing loss and has become an increasing public health concern due to rapid technological advancement, industrialization, and urban expansion worldwide. Noise-induced hearing loss (NIHL) can substantially impair communication, social functioning, and overall quality of life. Despite its preventable nature, epidemiological data on NIHL remain limited in many developing regions, including the Kurdistan Region of Iraq. **Objectives:** This study aimed to determine the prevalence of NIHL in Sulaymaniyah Governorate and to evaluate its distribution according to age and sex among individuals undergoing audiological assessment. **Materials and Methods:** Our study was a retrospective cross-sectional study in the Sulaymaniyah Governorate. The data was collected from the Shar Audiological Center and multiple private clinics from January 15, 2023, to January 17, 2024. Patients were categorized into NIHL, Normal, and Other. While data collection was localized to major urban centers, the sample is structurally representative of the broader Sulaymaniyah Governorate population due to regional healthcare infrastructure constraints. Public sector audiological services are highly centralized, with the Shar Audiological Center operating as the primary referral hub for the entire governorate. When overburdened, specialized private audiology clinics are the next point of contact. These in themselves are 4-5 clinics concentrated in the city center. Consequently, patients requiring audiological evaluation (including those residing in underserved rural and peri-urban districts) must travel to these centralized facilities. The sample therefore naturally aggregates a diverse demographic of cases from the governorate. Audiometric testing was conducted in a soundproof booth meeting American National Standards Institute (ANSI) standards. **Results:** Among 1,018 total cases, 287 were classified as NIHL, 331 as normal, and 420 as other diagnoses. Gender distribution: 18.66% of all the cases are male with NIHL, and 9.53% of all the cases are females with NIHL. Mean age differed significantly across groups, being 46.40 ± 13.67 years in NIHL, 31.77 ± 12.52 years in normal cases, and 48.18 ± 21.86 years in other diagnoses ($p < 0.001$). **Conclusion:** The compiled dataset revealed NIHL is a considerable health burden in Sulaimani Governorate, with 28.1% of the sampled population affected. Gender prevalence as well as comparison to other causes was also presented, giving an understanding of the proportionality.

Keywords: Noise-Induced Hearing Loss (NIHL), Audiometric Testing, Hearing Loss Prevalence, Sulaymaniyah Governorate, Public Health Impact.

Introduction

Noise-induced hearing loss (NIHL) occurs when loud noise damages structures within the inner ear. Typically, everyday sounds are safe unless they reach excessive volumes or are endured for extended periods. In such cases, exposure to loud or prolonged sounds can result in NIHL. Unlike other forms of hearing impairment, NIHL is preventable through appropriate measures, thereby alleviating the significant strain it could otherwise place on the healthcare system [1]. Many factors influence the severity of NIHL depending on the nature of the sound exposure. This includes factors like the intensity of the noise, the duration of exposure, and the frequency. The mechanism of NIHL is complex and involves a severe insult to the hair cells, resulting in permanent, irreversible loss. It involves several pathological pathways, including reduced blood flow, inflammation, the formation of Reactive Oxygen Species, Synaptopathies, and ultimately Apoptosis [6]. Over 5% of the world's population requires rehabilitation to address their disabling hearing loss. It is estimated that by 2050, over 700 million people will have disabling hearing loss [2].NIHL is the second most common cause of hearing loss following presbycusis (age-related hearing loss) [3]. The decibel scale is a major part of understanding NIHL. It is logarithmic; hence a 10-fold increase in intensity results in a 10-point difference from the baseline, and a 100-fold difference results in a 20-point difference. Sounds from 0dB up to 70dB are safe for exposure and are the noises that we hear on a daily basis. Exposure for 8 hours to 80dB is the cause of classical Occupational NIHL. Sounds ≥ 100dB are extremely hazardous, while ≥ 120dB result in immediate and permanent damage [4, 5].

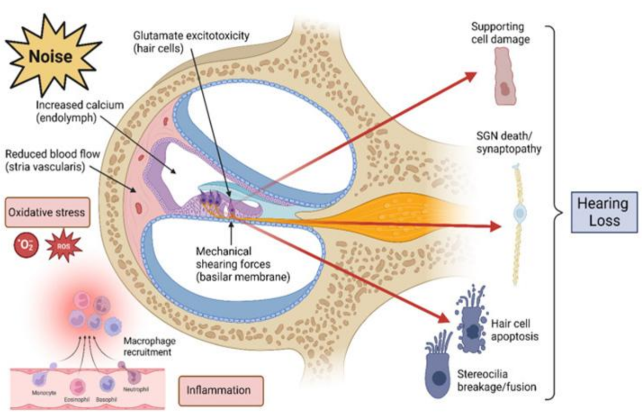


Figure 1: A combination of all of the different pathological pathways that combine to result in hair cell apoptosis and hearing loss [4].

Two different concepts crucial to understanding the pathophysiology of NIHL are Temporary Threshold Shift (TTS) and Permanent Threshold Shift (PTS): PTS is a change in hearing thresholds that is a product of stabilizing a new baseline of hearing due to damage and destruction of cochlear hair cells and nerve fibers associated with hearing [7]. If hearing loss persists for 14 - 30 days after the event, this is indicated as PTS [8]. In contrast, a transient hearing loss lasting 24-48 hours is known as TTS. This occurs due to temporary changes in the cochlea and auditory nerve function [9]. NIHL screening & diagnosis typically involves a combination of audiometry testing and assessment of noise exposure history. Audiometry tests are most typically done with PTAs [10]. NIHL typically produces a characteristic audiometric pattern on PTAs, where hearing is normal in low and mid frequencies, followed by a sudden drop on the graph past 3000 Hz, up until 4000 Hz, followed by a slight subsequent recovery in higher frequencies, resulting in a "notched" appearance which is typically diagnostic for NIHL [10].

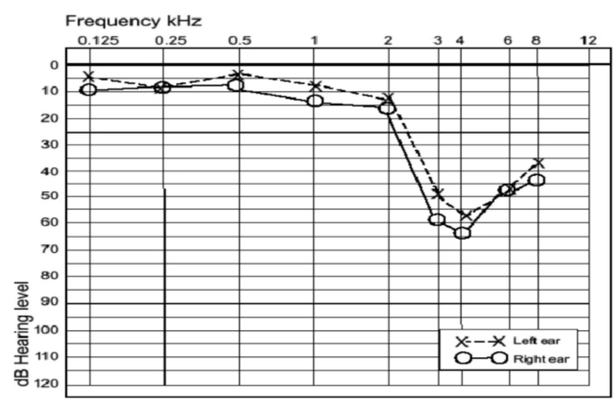


Figure 2: Above is a graph of PTA showing NIHL in the left ear with the characteristic notch [11].

NIHL is mostly preventable, and several steps can be taken to reduce the burden of the disorder, such as educational programs, regulations, and legislation to raise awareness and preemptively mitigate the damage caused by noise [12]. Hearing protective devices and earplugs play a crucial role in shielding against noise exposure [13]. There is no cure for NIHL. The clinical management of NIHL involves prevention of further progression with lifestyle changes and regular follow-up. Rehabilitation can be performed through hearing aids. Auditory Training can also be done, which provides programs to help individuals maximize their remaining hearing abilities [14]. Occupational NIHL is the most prevalent occupational disease worldwide [15]. OSHA (Occupational Safety and Health Administration) identifies US workers to be at an increased risk of NIHL if their noise exposure is ≥ 85 dB for 8 hours [16]. Environmental factors in urban areas and recreational activities are causes of NIHL for all individuals, with examples including (Urban Noises, vehicle noise, Recreational Shooting, Loud Music, Power Tools). Genetic and epigenetic factors influence susceptibility to NIHL in both animal models and humans [4]. This study aimed to determine the prevalence of NIHL in Sulaymaniyah Governorate and to evaluate its distribution according to age and sex among individuals undergoing audiological assessment.

Materials and Methods

Study Design and Setting

Our study was a retrospective cross-sectional study in the Sulaymaniyah Governorate. The data was collected from the Shar Audiological Center and private clinics to preserve the data's integrity and ensure diversity and accuracy. The samples were from the dates of January 15, 2023, to January 17, 2024.

Study Population

The data encompassed a diverse collection of individuals representative of the governorate's patient population.

Inclusion and Exclusion Criteria

Using the PTA record, our inclusion criteria were for NIHL, Normal and Other cases. Patients with other disorders (i.e., neither NIHL nor Normal) were labeled as “Other”. Our inclusion criteria were for patients with a history of hearing complaints, which was then followed by a PTA investigation, with the exclusion of ototoxic drug exposure.

Testing Methods

Audiometric testing was performed using a Madsen Astera, which is an audiometer (GN Otometrics, manufactured in Denmark) with TDH-39 air transducer headphone and B71 bone transducer in a soundproof booth meeting American National Standards Institute (ANSI) standards. Pure tone air conduction thresholds were measured at 0.5, 1, 2, 3, 4, 6, and 8 kHz. Hearing loss was categorized based on the WHO grading system as normal (<25 dB), mild (26-40 dB), moderate (41-60 dB), severe (61-80 dB), or profound (>80 dB) (15). The affected frequencies were identified based on the audiogram results.

Data Collection

Google Forms was used for data entry, providing a standardized approach and ensuring the data was comprehensive for future reference and reviews. The data was then transferred to Google Sheets for analysis. Demographic data for each case includes (Name, Gender, Date of Birth, Date of Visit). The affected ear was also recorded according to the audiogram and was labeled as (Both, Left, or Right).

Statistical Analysis

The data underwent analysis using the Statistical Package for the Social Sciences (SPSS) software, version 22.0. Initially, data entry took place in Google Sheets before being transferred to an SPSS file format (.sav). The dataset comprised both categorical and quantitative variables. Categorical variables were analyzed using frequency and percentage descriptive methods, while mean and standard deviation measures were employed for quantitative variables. For statistical inference, comparisons between variables were conducted using the Chi-square and ANOVA tests. A significance level of 0.05 was used, with p-values equal to or less than this threshold considered statistically significant. These metrics were visually represented through various graphical representations, including bar graphs and pie charts, designed to illustrate the distribution of hearing conditions across different demographics and other variables of interest.

Ethical Approval

Approval Number (179) was granted from the ethical committee of the College of Medicine/ University of Sulaimani, Iraq. The work was implemented in accordance with international guidelines and the 2008 Declaration of Helsinki. All personal information of the individuals from whom the data was collected is confidential and will not be shared with the public.

Results:

Figure 3 illustrates the overall distribution of the 1,018 study participants according to hearing status. Of the total sample, 420 (41.3%) were classified as having hearing disorders other than NIHL, 311 (30.6%) had normal hearing, and 287 (28.2%) were diagnosed with noise-induced hearing loss (NIHL). These findings indicate that approximately one in every four individuals undergoing audiological evaluation was diagnosed with NIHL, making it the second most common category after other hearing disorders.
Table 1a. Total Cases = 1018; NIHL = 287; Normal = 311 ; Other = 420.Mean Age and Standard Deviation for all 3 categories: NIHL = 46.400 years (Sd = 13.669) ; Normal = 31.771 years (Sd = 12.518) ; "Others" = 48.180 years (Sd = 21.863). Comparison of mean age and standard deviation between the different groups, which showed a P Value of <0.001, showing a statistical significance in the findings.

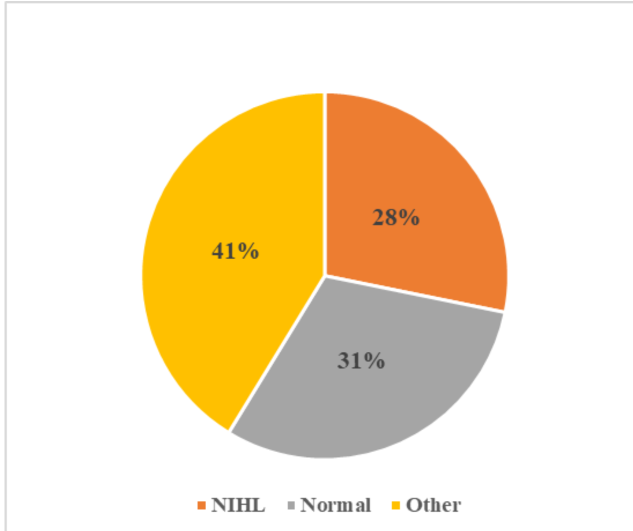


Figure 3: Pie Chart for the total distribution of the 1018 cases across Normal (31%), NIHL (28 %), and Other (41%).

Table 1b. The F-test for heteroscedasticity was statistically significant, $F(1, 1016) = 77.399$, $p < 0.001$, indicating the presence of heteroscedasticity. Thus, the assumption of constant variance of the residuals was violated. Table 1c. Presents the Bonferroni-adjusted pairwise comparisons of mean age between the three hearing diagnosis groups: NIHL, Normal, and Other. The analysis showed that patients in the NIHL group were significantly older than those in the Normal group, with a mean age difference of 14.629 years, SE = 1.413, $p < 0.001$, 95% CI [11.242, 18.016].

Table 1a: Comparison of mean age between different groups

Normal or NIHL	N	Mean Age (Year)	SD	P- Value
NIHL	287	46.401	13.6693	**< 0.001**
Normal	311	31.772	12.5185	
Other	420	48.181	21.8634	

Total	1018	42.666	18.7095	

Table 1b: F Test for Heteroskedasticity [a,b,c]

F	df1	df2	Sig.
77.399	1	1016	< 0.001

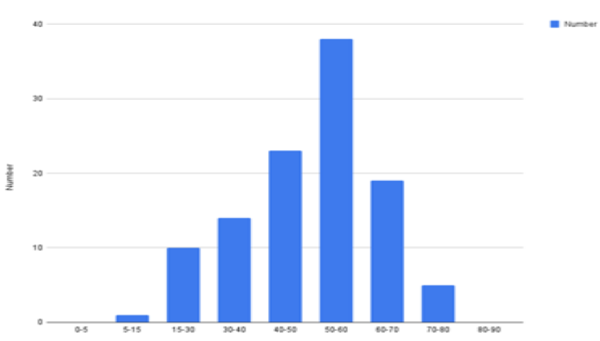
a. Dependent variable: Age (year)
b. Tests the null hypothesis that the variance of the errors does not depend on the values of the independent variables.
c. Predicted values from design: Intercept + Normal or NIHL

Table 1c: Pairwise Comparisons

(I) Normal or NIHL		Mean Difference (I-J)	Std. Error	Sig.[b]	95%Confidence Interval for Difference	
					Lower Bound	Upper Bound
NIHL	**Normal**	14.629*	1.413	< 0.001	11.242	18.016
	Other	-1.780	1.322	0.535	-4.950	1.389
Normal	**NIHL**	-14.629*	1.413	< 0.001	-18.016	-11.242
	Other	-16.409*	1.291	< 0.001	-19.505	-13.313
Other	**NIHL**	1.780	1.322	0.535	-1.389	4.950
	Normal	16.409*	1.291	< 0.001	13.313	19.505

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Bonferroni.

Figure 4 demonstrates the age distribution according to sex. Among males, the highest frequency of cases was observed in the 50-60 year age group, whereas among females the peak frequency occurred at approximately 40 years of age. These findings indicate that hearing-related conditions, particularly NIHL, were more frequently identified in older adults, with males tending to present at an older age than females.



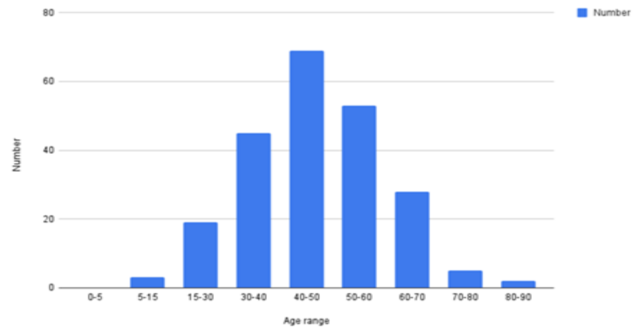


Figure 4: On the left shows the age distribution for males in the data set, and this is for all 3 categories, with a peak incidence in the 50-60 age range. On the right shows the age distribution for females with a peak incidence around the age of 40.

Figure 5 shows the gender distribution of the three diagnostic categories within the entire study population. Male patients with NIHL accounted for 18.66% of all participants, whereas female NIHL cases represented 9.53%. In contrast, normal hearing cases were similarly distributed between males (15.13%) and females (15.42%). Other hearing disorders constituted 23.38% of males and 17.98% of females. The association between gender and diagnostic category was statistically significant (p < 0.001), indicating a higher burden of NIHL among males.

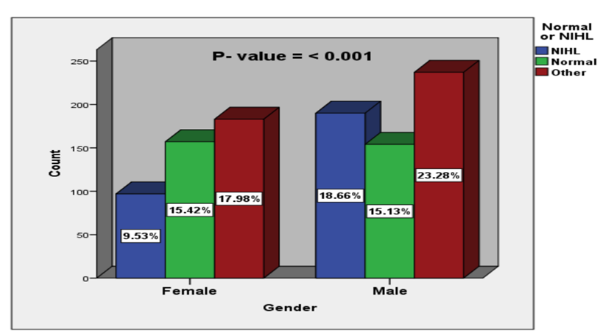


Figure 5: Gender distribution (in %) of the entire data set for all 3 variables is represented, where the % are a representation of the whole data set. Males: NIHL = 18.66%; Normal = 15.13%; "Others" = 23.38%. Females: NIHL = 9.53%; Normal = 15.42%; "Others" = 17.98%; P Value = <0.001. We can see NIHL has a nearly 2-fold increase from males to females, which highlights a key point in our research.

Table 2 presents the distribution of 1,018 patients across three hearing diagnosis categories (NIHL, Normal, and Other). Patients are further stratified by gender and affected ear (bilateral, left, or right), yielding a statistically significant P-value of <0.001. Among female patients (n=437), bilateral ear involvement was the predominant pattern across all diagnosis categories. It accounted for 57.7% (n=56) of NIHL cases, 100% (n=157) of Normal cases, and 76.5% (n=140) of other cases, with an overall bilateral rate of 80.8% (n=353). A similar pattern was observed in male patients (n=581). Bilateral involvement accounted for 64.2% (n=122) of NIHL cases, 99.4% (n=153) of Normal cases, and 82.7% (n=196) of other cases. This yielded an overall bilateral rate of 81.1% (n=471) for males. Unilateral involvement was less frequent in both genders, with left-sided cases slightly exceeding right-sided cases across most subgroups. Notably, Normal hearing cases were almost exclusively bilateral in both genders. Only one male case (0.6%) showed left-sided involvement, and no right-sided cases were recorded in either gender.

Table 2: comparison between NIHL with Affected Ear Cross tabulation in relation to gender

Gender				Affected Ear: Both	Left	Right	Total	P- Value
Female	Normal or NIHL	NIHL	Count	56	25	16	97	< 0.001
			%	57.7%	25.8%	16.5%	100%	
		Normal	Count	157	0	0	157	
			%	100.0%	0%	0%	100%	
		Other	Count	140	18	25	183	
			%	76.5%	9.8%	13.7%	100%	
	Total		Count	353	43	41	437	
			%	80.8%	9.8%	9.4%	100%	
Male	Normal or NIHL	NIHL	Count	122	39	29	190	
			%	64.2%	20.5%	15.3%	100%	
		Normal	Count	153	1	0	154	
			%	99.4%	.6%	0%	100%	
		Other	Count	196	23	18	237	
			%	82.7%	9.7%	7.6%	100%	
	Total		Count	471	63	47	581	
			%	81.1%	10.8%	8.1%	100%	

Involvement for total cases of both genders for both, left, or right ear: NIHL: Both = 62% (178) ; Left = 22.3% (64); Right = 15.7% (45).

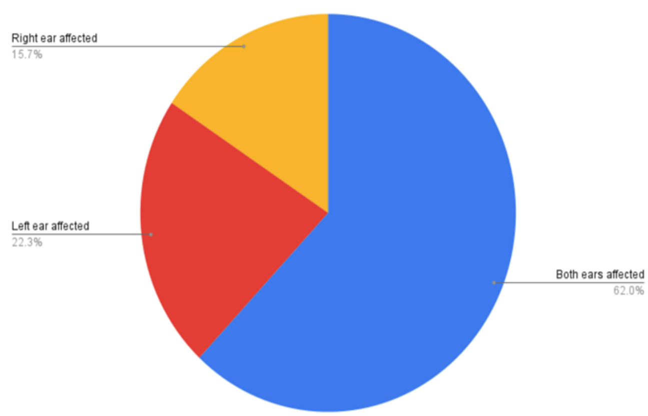


Figure 6: Shows the pie chart findings of Table 2.

Discussion

The total cases of NIHL in our sample showed a prevalence of 28.1%. The prevalence worldwide is also substantial, with the WHO reporting 2.5B cases by 2050. Additionally, over 1 billion young adults are at risk of developing the condition due to unsafe practices [1]. The CDC also estimated that one in four adults with healthy hearing has some measurable degree of NIHL, accounting for ~24% of the total population [4]. The standard deviation of the NIHL group suggests a broad age range, indicating that NIHL affects individuals across various age groups. This, alongside a P value of

($p < 0.001$) for the age association, shows a significant relationship of age to the development of NIHL. The findings in our population suggest that middle-aged adults are particularly vulnerable to NIHL, highlighting the importance of protective measures and regular hearing assessments for those in noisy occupations or environments. This is consistent with a British study that found that there was an 8-fold increase in reported severe hearing difficulty after the age of 55 as compared to teenagers and early adults [18]. A higher percentage of males have NIHL in our dataset. Males with NIHL consisted 18.66% of all collected cases, while females with NIHL, by contrast, accounted for 9.53% of all cases. Even when accounting for the higher number of males in the dataset, the male-to-female ratio of patients with NIHL was 1.47. A cross-sectional study in China found that the prevalence of HFHL in men (34.4%) was significantly higher than in women (13.8%), showing similar findings [19]. Research at the CDC similarly shows greater prevalence in males [17]. A study in Iran that compared samples from the urban and rural settings found that the prevalence is higher among men even in these different settings [20]. Most research is supportive of higher male prevalence. An intuitive explanation would be that males are more exposed to noise historically, while also participating in more recreational activities. Research has also found inherent biological differences in males. For example, studies have shown that testosterone may make the inner ear more vulnerable to noise-induced damage [19]. Table 2 shows ear involvement in NIHL for both genders. In females with NIHL, 57.7% had both ears affected, 25.8% left-only, and 16.5% right-only, indicating asymmetry. In males with NIHL, 64.2% had both ears affected, 20.5% right-only, and 15.3% left-only, again showing asymmetry. These results confirm that NIHL is predominantly bilateral but can be unilateral, with slight left-ear predominance. Further research is needed to understand this asymmetry. There are studies that indicate that the left ear might be more susceptible to noise damage compared to the right, regardless of factors like the "head shadow" effect, which traditionally suggested that the ear farther from the noise source (often the left ear, due to common right-handed firing positions or work habits) receives less noise exposure. This notion is challenged by findings that show left ear susceptibility could be more physiological rather than just situational [21]. In contrast, one study found no significant asymmetry related to occupational noise exposure when overall hearing loss was controlled. It concluded that while asymmetry increases with greater hearing loss, occupational noise itself is not a key cause. Instead, individual factors or pre-existing conditions may play a larger role [22]. Because of the lack of data in our country regarding asymmetry, it is a matter that needs further research to understand its underlying cause.

Implications of Findings

A mean age of (46.4 years) for individuals with NIHL compared to normal hearing and "Others" suggests that NIHL tends to affect older individuals. Age serves as a proxy for exposure and is not an identified risk factor; older patients are more affected because of their cumulative exposure to noise, rather than age itself being a risk factor for NIHL. NIHL affecting older individuals suggests that screening and awareness should focus on this demographic, who are more likely to have long-term noise exposure. The higher prevalence of NIHL among males might also indicate the need for gender-specific interventions and workplace policies for male workers. Hearing loss, being a significant burden, has been highlighted throughout our research. Indeed, the number of NIHL cases in our research aligns with the outlook of many literary sources, and our country, in comparison to developed countries, needs proper management and awareness.

Future Direction

There are some key takeaways from our research that we can act upon to decrease the burden of NIHL:

1. Enhancing data collection through the Implementation of electronic logging systems to capture demographic, residency and occupation data.
2. Establishing a population-based screening program to identify individuals with asymptomatic NIHL, focusing on the male population and older individuals.
3. Strict regulations and enforcement of occupational health and safety standards, particularly in industries with high noise exposure.
4. Conducting further research to investigate the impact of specific occupational settings on the development of NIHL.

Conclusion

Our study has compiled a substantial dataset, revealing that NIHL is a considerable health burden in our region. The analysis indicates that 28.1% of the sampled population is affected by NIHL, stressing its significance as a public health issue. The dominant bias in our data set is that sample is self-selected care seekers from specific clinics / hospitals which skews our findings to this specific group in terms of age, severity, symptom awareness, and male:female ratio. Another point within these cases is that exposure rate for and dB level was not accounted for in our study. Despite this, our findings provide critical insights into the prevalence and impact of NIHL. These insights advocate for implementing enhanced preventive and educational strategies, aiming to minimize the impact of NIHL. Future research should focus on longitudinal studies to track the progression of NIHL over time and evaluate the efficacy of new prevention strategies, with the aim of improving prevention and outcomes for the general population.

Informed Consent

Consent was taken from patients for data to be recorded in the computers and files of the Audiology departments from which the data was taken.

Authors' contributions

All authors contributed equally to the conception, design, data collection, analysis, and manuscript preparation. All authors read and approved the final version of the manuscript.

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Conflict of Interest

The authors declare **no conflicts of interest** related to this study.

Availability of Data and Materials

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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