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Prevalence and Causes of Hearing Impairment: A Cross-Sectional Study in Karnali, Nepal

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Abstract

Objective: To assess the prevalence, severity, and underlying causes of hearing impairments.

Methods: This cross-sectional study used multistage stratified sampling to select 2,148 individuals from Salyan and Surkhet, following WHO's Ear and Hearing Survey Handbook (2020).

Results: Among 1,946 participants, 38.9 per cent had hearing impairments, including 5.9 per cent with disabling hearing loss, with severity increasing with age. Ear diseases affected 34.3 per cent, including dull or retracted tympanic membranes (18%), impacted wax (8%), perforated tympanic membrane (6.1%), and abnormal tympanometry (23.1%). The major causes were age-related hearing loss (50.5%), eustachian tube dysfunction (23%), chronic suppurative otitis media (10.8%), and otitis media with effusion (4.7%). Higher education and immunization were associated with reduced risk, while chronic conditions, earaches, drainage, and tinnitus increased the risk.

Conclusion: The high prevalence of hearing impairment, primarily from preventable causes, underscores the importance of early screening and strengthened primary health care.

Keywords

Hearing impairment

Prevalence

Severity

Ear diseases

Causes

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Introduction

Hearing impairment (HI) is a global public health concern. Estimates indicate that more than 5.5 per cent of the population worldwide has moderate or worse hearing loss,[1] with about 90 per cent living in low- and middle-income countries, where resources to help are often limited.[2] Although HI often shows no visible signs, it affects around 6.1 per cent of the global population with disabling hearing loss.[3] The World Health Organization (WHO) projects that by 2050, nearly 2.5 billion people will experience hearing loss of mild or higher severity in the better hearing ear.[4]

In South-East Asia, 400 million people live with varying degrees of hearing loss, representing 25 per cent of the global cases.[5] According to Nepal's 2021 census, 15.6 per cent of country's population has a hearing disability, representing 2.2 per cent of total disabilities. The National Statistics Office (NSO) also found that 6.3 per cent of people in Nepal have speech impairment.[6] The Nepal Burden of Disease 2017 report highlights that nearly 4 per cent of Years Lived with Disability (YLD) comes from age-related hearing loss, which has risen by 31 per cent since 1990.[7]

HI is both a cause and consequence of poverty, especially in low and middle-income countries.[8] Ear health and hearing are shaped by a range of genetic, biological, psychological, and environmental factors throughout life, from prenatal to old age. Additionally, non-modifiable risk factors like age, gender, congenital factors, and medical conditions, loud noises, medications, diet, and occupational hazards all play a role in ear health. The occurrence, severity, and progression of hearing loss depend on the interaction of these factors.[9] When not identified early or effectively treated, it can hinder communication, language development, education, social life, cognitive function, and overall quality of life, leading to substantial costs for both individuals and society.[1] In Nepal, hearing loss appears to

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be more common than in other developing countries, possibly due to factors like lower socio-economic status, limited awareness, and inadequate healthcare facilities, particularly in rural areas.[10]

Nepal currently lacks a national survey on ear and hearing health. However, regional studies consistently show a high prevalence of hearing loss, exceeding WHO's threshold of 4 per cent, highlighting it as an urgent public health issue.[11] In Karnali Province, one of Nepal's most marginalized regions with a hard-to-reach population, the status of individuals with hearing difficulties remains unidentified. This study, therefore, aimed to assess the prevalence of hearing impairment in Surkhet and Salyan districts of Karnali province and to identify potential causes.

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Materials and Methods

The cross-sectional study was conducted in six municipalities—three in each of Salyan and Surkhet districts—from 17 February to 16 March 2024. The research followed the guidelines outlined in WHO's Ear and Hearing Survey (EHS) Handbook (2020), which was designed to estimate hearing impairment prevalence, including age- and gender-specific rates, to assess different grades of hearing loss according to WHO standards, and to identify common causes of hearing loss in these districts.

Study population

The study included individuals of all ages, backgrounds, and disabilities from randomly selected households, excluding those who had lived in the area for less than six months. To avoid selection bias, the chosen households were given a "yellow card" with family details, which was required for participation. Only individuals with this card could participate, while self-reported individuals without it were excluded.

Sampling strategy

The study used a stratified multistage cluster sampling approach. The population was first divided into two main groups (strata) by district: Surkhet and Salyan. Within each district, local levels served as secondary strata. Each ward within a local level was treated as a separate cluster. In the first stage, the clusters were selected using the Probability Proportional to Size (PPS) method. After choosing wards, each selected ward was further divided into blocks, and lists of neighbourhoods (*toles*) and households were obtained from ward offices and organized into distinct blocks. In the second stage, one block was randomly selected from each ward using simple random sampling. A household listing process was conducted following the block selection, and, in the third stage, a systematic random sampling technique was applied to select households within each chosen block. Finally, in the

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fourth stage, all eligible individuals within the selected households were included in the study.

Sample size

Based on WHO's 5.5 per cent prevalence of hearing loss,[1] with a precision of 1.5 per cent, an 85 per cent participation rate, and a design effect of two to adjust for homogeneity within-cluster, the required sample size was calculated to be 2090. To ensure maximum population coverage, a 20 per cent dropout rate was added, bringing the final sample size of 2508 individuals. With a total of 78,231 households and an average family size of four, the number of households to be surveyed was 627. And, given a cluster size of 30, this required selecting 21 households per cluster (i.e., 627/30).

Sampling frame

Based on data from the 2021 National Population and Housing Census, the total population in the study area included 321,565 individuals: 93,543 in Salyan and 228,022 in Surkhet. The sample distribution across the selected municipalities, determined using the PPS sampling technique, is shown in Table I.

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Table I: Sampling distribution for study site

Strata- Salyan			
Local level strata	**Total household**	**Selected wards**	**Estimated Sample Size per cluster**
Kumakh Gaunpalika	5,491	1,4	42
Bagachour Municipality	7,498	1,4,8	63
Sharada Municipality	8,898	1,4,9,14	84
Total	**21,887**	**9**	**189**
Strata- Surkhet			
Gurbhakot Municipality	11,798	3,6,9,12	84
Birendranagar Municipality	38,377	1,2,3,4,5,6,7,9,10,11,12,14	315
Barahatal Gaunpalika	6,169	4,7	42
Total	**56,344**	**21**	**441**

**National Population and Housing Census 2021* *3,9,12: - wards selected twice under PPS*

Study tool and instruments

The survey tool was developed following the EHS Handbook guidelines and included sections on demographic information and exposure to risk factors. The study also included clinical assessments, such as otoscopic examinations, tympanometry, and audiological tests like Otoacoustic Emissions (OAE) and Pure-Tone Audiometry (PTA). These tests were used to identify and measure the extent of hearing loss and ear diseases.

Research team and training

An eight-member team conducted the fieldwork over 31 days. It consisted of one ENT specialist, two ear and hearing care workers, three researchers, and two local volunteers. Prior

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to data collection, the ear and hearing care workers and researchers underwent an eight-day online training program and a two-day practical training session. This training was based on WHO's standard protocol for intermediate-level proficiency and covered topics from modules 1–9 of the Primary Ear and Hearing Care Training manual, with some adjustments for local context.[13]

Pilot study and presurvey visit

A pilot study was carried out in Bheriganga Municipality, Surkhet, in similar settings. Feedback from the field team and participants was collected and used to adjust and improve the survey tool before starting the main survey. A presurvey visit was also conducted to prepare for the actual survey, during which the study team coordinated with municipal and ward offices, gathered information on neighbourhoods and households, formed blocks, randomly selected blocks within clusters, conducted social mapping, and finalized the campsite location.

Data collection

Before data collection, local volunteers created a household roster using the Kobo Toolbox software to ensure all eligible individuals were included. They explained the study's objectives to households and encouraged them to attend a designated camp. Data collection involved community-based camps, household visits, or a mixed approach to minimize dropout rates. It was conducted in three phases: face-to-face interviews for socio-demographic and medical history, hearing assessments, and ear examinations.

Hearing assessment: Before beginning the hearing assessment, ambient noise levels were checked and kept below 40 dBA. Children aged 0-4 years underwent OAE testing, while those aged five and above took PTA tests using the Arphy Proton Dx3 audiometer. Air

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conduction thresholds for both ears were measured at 500Hz, 1000Hz, 2000Hz, and 4000Hz and recorded in the personalized data collection form.

Ear examination: After the hearing tests, patients were moved to a designated room for a comprehensive ear examination. An otoscope was used to inspect the ear canal and tympanic membrane for any abnormalities or signs of disease.

Tympanometry: Tympanometry was conducted to assess middle ear function and detect issues related to the eardrum, middle ear cavity, and ossicles.

Data management and analysis

After fieldwork was completed, trained individuals, following a proper orientation, entered the data into the system using Kobo Toolbox. Supervisors then thoroughly checked, reviewed, and corrected the uploaded data. Next, data cleaning and validation were conducted to rectify errors or inconsistencies. The data were then transferred to the SPSS software for management and analysis, and syntax was set up for the survey dataset.

In the analysis, both descriptive and inferential statistics were used to understand the prevalence, causes, and risk factors for hearing loss among people in the study area. Frequencies and percentage were calculated for the descriptive part. Inferential statistics included the chi-square test and logistic regression. Only variables that showed significant associations in univariate analysis were included in the multivariate analysis—these included variables with a p-value below 0.05 at a 95% confidence interval.

Definition of hearing impairment

In accordance with the EHS Handbook, HI was calculated using a threshold of above 20 dBHL in the better ear. Grades of hearing loss were determined based on the average hearing level in the better ear at 0.5, 1, 2, and 4 kHz on PTA, as follows:

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Mild = Above 20 to below 35 dBHL

Moderate = 35 to below 50 dBHL

Moderate to severe = 50 to below 65 dBHL

Severe = 65 to below 80 dBHL

Profound = 80 to below 95 dBHL

Complete = 95 dBHL or higher

Unilateral hearing loss was identified when the better ear measured below 20 dBHL and the worse ear measured 35 dBHL or more.[12]

Ethical consideration

The Nepal Health Research Council (NHRC) approved the study, with protocol registration number 689/2023, on 9 January 2024. Before data collection began, informed consent was obtained from all participants, who were also told they could leave the study at any time without any consequences. Confidentiality and anonymity were rigorously upheld throughout the study. In addition, since the survey included individuals of all ages from selected households, parental consent was obtained for participants under 18.

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Results

Socio-demographic information

Out of the 2148 study participants, 58.8 per cent were female. The predominant age group was 15–44 years, making up 39.3 per cent of the total. Notably, females outnumbered males in this group by 17 per cent.

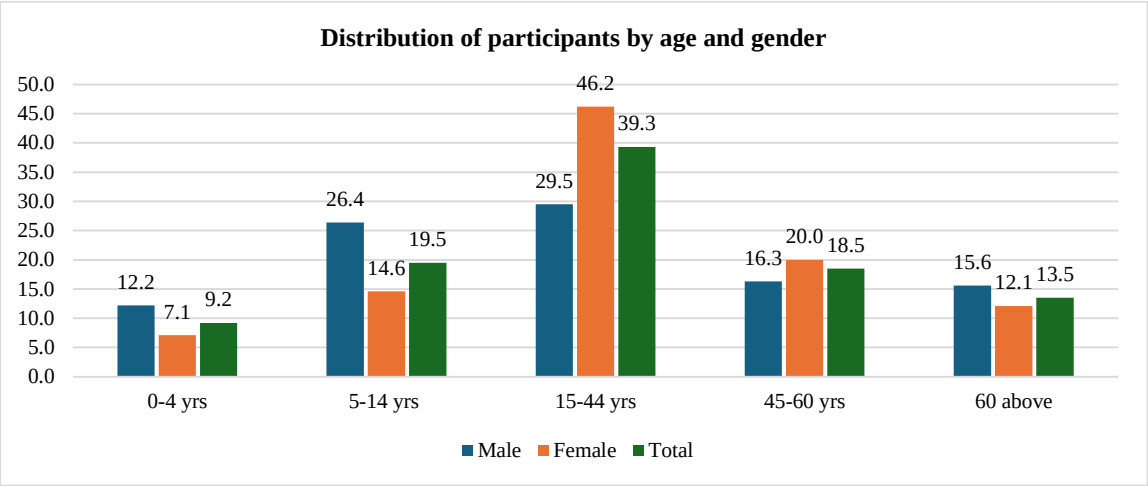

Figure 1: Distribution of participants by age and gender

General ear and hearing health status

More than one third (36.4%) of participants experienced tinnitus, which affected their sleep (59.7%), concentration (56.0%), work (56.6%), and daily activities (39.6%). The study also found that 27.5 per cent had a history of frequent earaches, 12 per cent experienced ear discharge, and 1.6 per cent had already undergone ear surgery. Over half (55.7%) were immunized according to the national schedule, and 14.9 per cent had relatives with hearing difficulties. Only 1.5 per cent reported hearing loss possibly due to ototoxic drugs. Furthermore, 35.4 per cent had daily exposure to loud sounds, and 16.5 per cent used headphones at varying levels.

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Table II: General ear and hearing health status

Characteristics	Frequency	Percentage
Tinnitus experience		
Yes	781	36.4%
No	1112	51.8%
Uncertain	255	11.9%
History of earache		
Yes	591	27.5%
No	1496	69.6%
Uncertain (in case of children who cannot report by themselves)	61	2.8%
History of discharging/draining ears		
Yes	257	12.0%
No	1891	88.0%
History of ear surgery		
Yes	34	1.6%
No	2114	98.4%
Immunization coverage		
Yes	1197	55.7%
No	431	20.1%
Uncertain	520	24.2%
Have relatives with difficulty in hearing		
Yes	320	14.9%
No	1821	84.8%
Uncertain	7	0.3%
Experience of ototoxic effect on hearing		
Yes	33	1.5%

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Characteristics	Frequency	Percentage
No	1665	77.5%
Uncertain	111	5.2%
Not applicable	339	15.8%
Exposure to loud sound		
Never	225	10.5%
Once a month or less	375	17.5%
2-3 times per month	404	18.8%
Once a week	383	17.8%
Almost every day	761	35.4%
Use of headphones		
Never	1594	74.2%
Once a week or less	102	4.7%
2-3 times per week	157	7.3%
Everyday	56	2.6%
As per need	41	1.9%
Not applicable	198	9.2%

Prevalence and distribution of hearing impairment in different age groups

A total of 198 children under the age of five underwent OAE testing to assess their hearing capacity. Of these, 80.3 per cent passed the test, while the remaining 19.7 per cent were referred for further evaluation.

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Table III: OAE test for children aged 0-4 years.

OAE test	Male		Female		Total	
	N	%	N	%	N	%
Pass	84	77.8%	75	83.3%	159	80.3%
Refer	24	22.2%	15	16.7%	39	19.7%
Total	**108**	**100.0%**	**90**	**100.0%**	**198**	**100.0%**

Four participants over age five were unable to undergo PTA due to intellectual disability. Of the remaining 1946 participants who underwent PTA, 38.9 per cent had hearing impairment. Mild hearing impairment affected 19.6 per cent of participants, with only four experiencing complete hearing loss or deafness. Age was significantly associated with hearing loss ($\chi 2$: 855.471, p-value: 0.000). Age analysis showed that 93.8 per cent of individuals over 60 exhibited some degree of hearing loss, followed by 62 per cent in the 45-60 age group, 23.5 per cent in the 15-44 age group, and 10.1 per cent in the 5-14 age group.

Table IV: Prevalence and Distribution of hearing impairment in different age groups (n=1946)

Grades of hearing impairment	5-14 years	15-44 years	45-60 years	60 above years	Total %	N
Mild	5.3%	14.6%	34.5%	34.0%	19.6%	381
Moderate	2.6%	3.3%	15.6%	32.3%	10.0%	195
Moderate to severe	-	1.4%	6.8%	14.8%	4.2%	82
Severe	-	0.7%	1.8%	9.6%	2.1%	41
Profound	-	-	0.8%	2.1%	0.5%	9
Complete	-	0.2%	0.3%	0.3%	0.2%	4
Unilateral	2.2%	3.2%	2.3%	0.3%	2.4%	46
Overall prevalence	10.1%	23.5%	62.0%	93.8%	38.9%	758

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Grades of hearing impairment	5-14 years	15-44 years	45-60 years	60 above years	Total %	N
Chi square ($\chi 2$): 855.471, p-value: 0.000						

Distribution of hearing impairment according to gender differences

Although the overall prevalence of hearing impairment shows no significant gender differences in the bivariate analysis, specific age groups showed variations. Females generally have a higher prevalence of mild hearing impairment than males, except in the 5-14 age group, with the total proportion in females exceeding males by 12.2 per cent. In contrast, males have a higher prevalence of moderate hearing impairment across all age groups except 5-14 years, with females having 8.6 per cent less moderate impairment overall.

Table V: Distribution of hearing impairment according to gender differences in different age groups (n=758)

Grades of HI	5-14 years		15-44 years		45-60 years		60 above		Total	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Mild	60.0%	41.2%	48.1%	67.4%	52.7%	57.4%	30.5%	41.8%	42.9%	55.1%
Moderate	24.0%	29.4%	24.1%	10.4%	25.3%	25.2%	38.9%	30.5%	30.9%	22.3%
moderate to severe	-	-	11.1%	4.2%	16.5%	7.7%	17.6%	14.2%	14.6%	8.3%
Severe	-	-	1.9%	3.5%	4.4%	1.9%	9.2%	11.3%	5.6%	5.3%
Profound	-	-	-	-	-	1.9%	3.1%	1.4%	1.3%	1.1%
Complete	-	-	1.9%	0.7%	1.1%	-	-	0.7%	0.7%	0.4%
unilateral	16.0%	29.4%	13.0%	13.9%	-	5.8%	0.8%	-	4.0%	7.4%
Total	**25**	**17**	**54**	**144**	**91**	**155**	**131**	**141**	**301**	**457**

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Disabling hearing loss

Participants with hearing loss greater than 35 dBHL in the better ear were classified as having disabling hearing loss, with a prevalence of 15.9 per cent. The prevalence rate increased with age, reaching 57 per cent in those aged 60 and above. When disaggregated by gender, males were 5.5 per cent more affected by disabling hearing loss than females. In all age groups except 5-14 years, males had a higher prevalence of disabling hearing loss.

Table VI: Prevalence of disabling hearing loss according to age and sex differences

Age group	Gender	Disabling	Non-Disabling
5-14 years	Male	1.3%	98.7%
	Female	2.7%	97.3%
	Subtotal	1.9%	98.1%
15-44 years	Male	7.7%	92.3%
	Female	4.0%	96.0%
	Subtotal	5.1%	94.9%
45-60 years	Male	27.1%	72.9%
	Female	20.9%	79.1%
	Subtotal	23.2%	76.8%
60 above	Male	63.0%	7.6%
	Female	51.6%	48.4%
	Subtotal	57.0%	43.0%
Overall	Male	19.2%	80.8%
	Female	13.7%	86.3%
	Total	**15.9%**	**84.1%**

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Ear diseases

An otoscope and tympanometry were used to examine participants' ears, revealing that 737 individuals (34.3%) had ear diseases in either one or both ears. Among the findings, 0.7 per cent had malformed auricles, such as preauricular sinus, 0.5 per cent had ear trauma, and 0.1 per cent had a pinna infection. Wax was present in 19.6 per cent, with 8 per cent having impacted wax. Foreign bodies were found in 0.7 per cent, and 0.2 per cent had inflammation of the external ear canal. Otorrhoea (the discharge of fluid or pus) and fungal infections affected 1.9 per cent and 1.8 per cent, respectively, in the external ear canal. A dull or retracted tympanic membrane was observed in 18 per cent, and 6.1 per cent had perforated tympanic membrane. A red and bulging tympanic membrane—indicating upper respiratory infection, chronic allergies, or sinusitis—was seen in 2.3 per cent. Otorrhoea in the middle ear affected 2.2 per cent, and cholesteatoma was found in 0.6 per cent of. Abnormal tympanometry results were observed in 23.1 per cent of participants.

Table VII: Ear diseases found in either or both ears (N=2148)

Conditions	Frequency	Percentage
Pinna		
Auricle malformation	14	0.7%
Auricle trauma	11	0.5%
Auricle infection	2	0.1%
External Ear Canal		
Impacted wax	171	8.0%
Foreign body (FB)	15	0.7%
Inflammation of ear canal	5	0.2%

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Conditions	Frequency	Percentage
Otorrhea of external ear	40	1.9%
Fungus (Otomycosis)	38	1.8%
Tympanic membrane		
Perforation	131	6.1%
Dull and retracted	386	18.0%
Red and bulging	50	2.3%
Middle ear		
Otorrhea	48	2.2%
Cholesteatoma	13	0.6%
Abnormal tympanometry	497	23.1%

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Probable cause of hearing loss

The probable causes of hearing loss were analysed based exclusively on the threshold of the better ear. The primary cause of hearing loss at any level was age-related hearing loss (ARHL), making up 50.5 per cent, followed by eustachian tube dysfunction (ETD) at 23 per cent, chronic suppurative otitis media (CSOM) at 10.8 per cent, wax impaction at 7 per cent, otitis media with effusion (OME) at 4.7 per cent, and sensorineural hearing loss (SNHL) at 2.2 per cent. However, the cause of hearing loss was unknown for 5.4 per cent of participants. It is observed that ETD was mainly associated with mild to moderate hearing loss, while ARHL was linked to moderate, moderate to severe, severe, and profound hearing loss. Similarly, idiopathic SNHL was most often associated with complete hearing loss.

Table VIII: Probable causes and grades of hearing loss amongst those with any level of hearing loss (n=758)

Causes	Mild	Moderate	Moderate to severe	Severe	Profound	Complete	Unilateral (cause in worse ear)	Total Frequency	Total percentage
Unknown	8.1%	1.5%	-	2.4%	-	25.0%	10.9%	41	5.4%
Wax	6.8%	9.2%	7.3%	2.4%	11.1%	-	2.2%	53	7.0%
CSOM	7.6%	8.2%	13.4%	17.1%	33.3%	-	34.8%	82	10.8%
OME	5.2%	5.1%	2.4%	2.4%	-	-	6.5%	36	4.7%
AOE	0.3%	0.5%	-	-	-	-	-	2	0.3%
ASOM	1.0%	0.5%	-	-	-	-	-	5	0.7%

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FB	-	0.5%	-	-	-	-	-	1	0.1%
ARHL	36.5%	70.8%	78.0%	75.6%	88.9%	25.0%	4.3%	383	50.5%
SNHL	0.8%	2.6%	3.7%	2.4%	-	25.0%	8.7%	17	2.2%
Congenital	-	-	-	4.9%	-	50.0%	-	4	0.5%
NIHL	0.5%	0.5%	1.2%	-	-	-	-	4	0.5%
ETD	35.2%	11.3%	3.7%	2.4%	-	-	30.4%	174	23.0%
Otosclerosis	-	1.0%	-	-	-	-	-	2	0.3%
Sequelae of Otitis media	0.5%	1.0%	-	-	-	-	2.2%	5	0.7%
Cerebral palsy	-	-	**1.2%**	-	-	-	-	**1**	**0.1%**
N	**381**	**195**	**82**	**41**	**9**	**4**	**46**	**758**	**100.0%**

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Risk factors analysis

The variables (age, gender, education status, income, smoking, chronic medical conditions, immunization status, family history of hearing loss, ototoxic effects, use of headphones, exposure to loud sound, history of earache, history of ear drainage, and tinnitus) were initially included in the model. However, only those with a p-value of 0.05 or less were retained. Age, considered a confounding factor, was excluded from the final analysis. Thus, the final model included education status, chronic medical conditions, immunization status, history of earache, smoking habits, history of ear draining, and tinnitus experience.

Higher education reduced the likelihood of hearing impairment by 91.2% compared to illiteracy (OR: 0.088, 95% CI: 0.052-0.150). Similarly, secondary (OR: 0.147, 95% CI: 0.091-0.238) and primary education (OR: 0.159, 95% CI: 0.103-0.245) were associated with a lower likelihood of hearing impairment. Participants with chronic medical conditions had 3.264 times higher odds of hearing impairment (OR: 3.264, 95% CI: 2.165-4.922). Immunised participants following the national schedule were 51% less likely to experience hearing impairment (OR: 0.490, 95% CI: 0.368-0.650). Those with a history of frequent earaches had 1.512 times higher odds of hearing impairment (OR: 1.512, 95% CI: 1.120-2.042). Participants with draining ears had 2.360 times higher odds of hearing impairment (OR: 2.360, 95% CI: 1.604-3.471), and those with tinnitus had 2.019 times higher odds (OR: 2.019, 95% CI: 1.543-2.642). Smoking did not show a significant association in multivariate analysis.

Table IX: Multivariate analysis of risk factors

Factors	Hearing impairment		
	AOR	95% CI	P- value
Education			
Higher secondary	0.088	0.052-0.150	0.000
Secondary	0.147	0.091-0.238	0.000
Primary	0.159	0.103-0.245	0.000
Illiterate	Ref		
Chronic medical conditions[a]			
Present	3.264	2.165-4.922	0.000
Not present	Ref		
Immunization status			
Yes	0.490	0.368-0.650	0.000
No	Ref		
History of earache			
Yes	1.512	1.120-2.042	0.007
No	Ref		
Habit of smoking			
Yes	1.452	0.910-2.314rik	0.117
No	Ref		
History of Ear draining			
Yes	2.360	1.604-3.471	0.000
No	Ref		
Tinnitus experience			
Yes	2.019	1.543-2.642	0.000

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No	Ref

[a]Chronic medical conditions encompass diabetes, hypertension, kidney diseases, hypercholesterolemia, and rheumatic diseases.

Action needed

Among the participants examined, 682 (31.8%) required actions or services. Of them, 77 per cent needed medications, 14.7 per cent required hearing aids, and 16.6 per cent were referred for further evaluation, possibly including additional diagnostics or treatment such as surgery. Only a small number (0.6%) were urgent cases needing advanced diagnostics for medication.

Table X: Population in need of ear and hearing services

Action needed		Frequency	Percentage
Yes (682)	Medication	525	77.0%
	Hearing aids	100	14.7%
	Referral for further evaluation	113	16.6%
	Urgent referral	4	0.6%

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Discussion

This cross-sectional, community-based study provides insights into the prevalence and levels of hearing loss, along with etiological causes and risk factors, across all age groups in the Salyan and Surkhet districts of Karnali Province, Nepal. The study followed WHO's EHS Handbook (2020), and used a mixed data collection method through household visits and camp-based assessments. During visits and camps, participants were directed to a hearing assessment room with ambient noise below 40 dBA after initial history-taking. Hearing assessments were carried out before any ear examination as per protocol, as actions like removing wax, debris, discharge, or foreign objects could have affected true hearing results, avoiding any potential bias from the audiologists.

Audiometry measurements followed WHO guidelines, averaging four air conduction frequencies. While mobile devices can estimate hearing threshold accurately[14], this survey applied classical pure-tone audiometry tests (with battery backup). Bone conduction was not tested, hence some cases were labelled as unknown as they needed a comprehensive evaluation to determine the cause.

This study also highlights tinnitus as a significant public health issue, affecting over one third of the population. More than half of those with tinnitus reported disturbances in sleep, concentration, and work—a higher rate than a recent study in Nepal, which reported an 11.7 per cent incidence in adults.[15] Further research using the Tinnitus Handicap Inventory is recommended.

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The study revealed a concerning prevalence of hearing impairment at 38.9 per cent, which is higher than the 16.6 per cent found in a 2007 study in Nepal.[16] However, this difference may be due to methodological disparities. The earlier study defined hearing impairment as a threshold worse than 30 dB in either ear. Additionally, the timing of the studies may also have influenced the variation in results. This survey introduced a new grading system for hearing loss in Nepal, making direct comparisons with past studies less relevant.

The prevalence of disabling hearing loss in this study was 15.9 per cent, which is higher than the 6.1 per cent found in the WHO Ear and Hearing Disorders Survey in Guizhou Province, China. However, methodological differences also contributed to this variation: this study defined disabling hearing loss as greater than 35 dB in the better ear, while the Guizhou study[17] used thresholds of more than 40 dB for adults and greater than 35 dB for children.

The analysis showed a strong link between age and hearing impairment severity ($\chi 2$: 855.471, p-value: 0.000), with hearing impairment increasing with age. The prevalence ranged from 23.5 per cent in the 15–44 age group to 93.8 per cent to those aged 60 and above. This trend aligns with results from the Guizhou Province study, which also showed a significant increase in hearing loss with age ($\chi 2 = 2049.866$, $p < 0.01$), reaching 72.6 per cent among those aged 60 or older.[17] Similarly, a study in France showed that hearing loss prevalence increased from 3.4 per cent among individuals aged 18–25 to 73.3 per cent among those aged 71 to 75 years.[18] Among children aged 5-14, hearing impairment was found in 10.1 per cent, aligning with a previous study in Nepal, which reported a 10.75 per cent prevalence in children aged 5-19.[19] However, this rate is higher than the 5.73 per cent prevalence found in school-aged children across 509

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government school in Nepal's hill, mountain, and Terai regions.[20] This suggests a need for targeted preventive interventions for children.

There was no significant difference in overall prevalence of hearing loss amongst male and female. However, differences in the prevalence of mild, moderate, and moderate-to-severe hearing impairment were observed within certain age groups as males were more affected by moderate and moderate to severe level of hearing loss for all age group expect 5-14 years. A similar study in Jiangxi Province, China, found that females had 0.73 times lower odds of hearing loss than males.[21] Likewise, another study in China reported that males had 2.27 times the risk of hearing loss compared to females.[17] These contradictory findings suggest further research is needed to determine whether gender is a risk factor for hearing loss.

The prevalence of ear diseases was determined to be 34.3 per cent. This included any ear disease detected in one or both ears, with some individuals showing multiple conditions simultaneously. This prevalence rate is notably higher than the 18.8 per cent reported in a 2021 study by the Curative Services Division of the Ministry of Health and Population.[22] The prevalence calculation was based on the presence of diseases affecting the pinna, external ear canal, tympanic membrane, and middle ear. Impacted wax was identified in 8 per cent of participants, a figure higher than the 3.4 per cent prevalence documented in a 2010 study conducted in Sarlahi, Nepal.[23] Further examination by age group showed that impacted wax was present in 14.6 per cent of participants aged 5–14, while 6.2 per cent of participants aged 60 and above had a perforated tympanic membrane (TM). These findings are consistent with a study from Ecuador, where 13.7 per cent of participants aged 4–15 had impacted wax, and 2 per cent of those aged 65 and above had a perforated TM.[24]

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Almost 18 per cent of study exhibited a dull and retracted tympanic membrane, a sign often associated with untreated middle ear infections, nasal infections, or poor Eustachian tube function. Although this figure is slightly lower than that reported in a study from Eastern Nepal[23], it still highlights a concerning proportion that requires attention. Additionally, 7 per cent of participants had hearing loss due to impacted wax, an easily treatable condition. With proper ear and hearing care, these conditions could have been prevented. Cholesteatoma, a potentially life-threatening condition that signifies an unsafe disease in the middle ear cavity, was found in 13 participants. Some patients showed signs of sensorineural hearing loss, which requires further investigation to determine the likely cause. For about 5 per cent of participants, the cause of hearing loss was unclear and needed further audiological investigations, including tests such as bone conduction and acoustic reflex to determine if the hearing loss is sensory, conductive, or mixed. Additionally, blood and imaging tests may be necessary for accurate diagnosis.

This study identified ARHL as the most common cause of hearing loss, predominantly linked with moderate to severe hearing impairment. The WHO Ear and Hearing Disorder Survey from Guizhou Province reported that presbycusis (ARHL) accounted for over 30 per cent of hearing loss[17], a slightly lower percentage than observed in this study. Though ARHL is primarily age-related, various factors can worsen its impact, including comorbidities (such as hypertension, diabetes, chronic kidney disease, and lung disease), exposure to noise, the use of ototoxic drugs, stress and anxiety.[25] Following ARHL ETD was the next most common cause of hearing loss identified in this study. ETD, however, mainly resulted in mild or one-sided hearing loss. As a preventable condition, ETD's effects can be mitigated through proper ear and hearing care.

CSOM was the third leading cause of hearing loss in this study. Previous research in Nepal[22], has consistently highlighted CSOM as a major contributor to hearing impairment, contrasting with

findings from developed countries, where chronic middle-ear disease (both active and inactive) is the most prevalent ear condition, with a prevalence of 5.3 per cent.[26]

Upon analysing the link between risk factors and hearing loss, this study found no significant association between gender and hearing impairment, which contrasts with a previous study that suggested males were at a higher risk than females.[24] Education level, however, was found to have a significant association with hearing impairment, although this result contradicts another study that did not find literacy levels to be influential.[23] Immunisation appeared to be a protective factor against hearing impairment, consistent with findings from another study in Nepal.[22] Chronic medical conditions were also significantly associated with hearing impairment, aligning with previous research. Other studies similarly support the connection between chronic conditions, ototoxic medication, and hearing impairment.[24,27] In this study, 14.8 per cent participants needed hearing devices, and 16.6 per cent required further diagnostic evaluation. These findings underscore the importance of timely and appropriate diagnosis and effective treatment, as well as access to high-quality hearing devices.

Strength and limitations

This study has several strengths. It is a pioneering effort, as no similar study had previously been conducted on such a large population using robust multi-stage sampling techniques for participant selection. Validated clinical tools were employed, and the insights gained from this research can guide and enhance future studies in other regions of Nepal. The findings will aid in developing more effective interventions for ear and hearing health. However, there were some limitations. Due to infrastructure challenges, a soundproof environment could not be established at all study sites, affecting the accuracy of hearing threshold assessments. Additionally,

conducting OAE tests on children was challenging when they were not asleep. Assessing hearing status after the removal of earwax or foreign bodies could also improve the study's accuracy.

Conclusion

Hearing impairment in Karnali Province represents a significant public health issue, with particularly high prevalence among older adults. These findings highlight an urgent need for targeted public health initiatives to address hearing impairment in the province. Recommended strategies include increasing awareness about ear and hearing health, enhancing access to audiological services, and implementing preventive measures such as immunization and noise control. Additionally, the high prevalence of treatable conditions like CSOM, ETD, and wax impaction also indicates that strengthening primary healthcare services could significantly reduce the burden of hearing impairment. Addressing socio-demographic disparities and improving access to ear and hearing care can substantially mitigate the impact of hearing impairment across Karnali Province.

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Summary

- Despite global progress in ear care, Nepal's Karnali Province faces significant gaps in diagnostics and treatment access, compounded by limited resources and specialized workforce. Other public health improvements contrast with unaddressed hearing health, necessitating prevalence data for informed policymaking.
- Among 1,946 participants (aged ≥5 years), 38.9% exhibited hearing impairment, escalating with age. Disabling hearing loss affected 15.9%, with males 5.5% more impacted than females.
- Ear pathologies were found in 34.3% of individuals, with common conditions including retracted tympanic membranes (TM), impacted wax, and TM perforations.
- Immunization and education correlated with reduced risk, while earache, drainage, and tinnitus were linked to higher hearing loss rates.
- As the first population-based prevalence survey in Karnali, this study underscores urgent needs for accessible diagnostics, targeted interventions, and integration of ear care into primary health systems to address preventable and treatable conditions.

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