

## **Prevalence and causes of hearing impairment in Fundong Health District, North West Cameroon**

Short title: Hearing impairment in Cameroon

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## Abstract

**Objective:** To estimate the prevalence and causes of hearing impairment in Fundong Health District, North West Cameroon.

**Methods:** We selected 51 clusters of 80 people through probability proportionate to size sampling. Initial hearing screening was undertaken through an otoacoustic emission (OAE) test. Participants aged 4+ years who failed this test in both ears or for whom an OAE reading could not be taken underwent a manual pure-tone audiometry (PTA) screening. Cases of hearing impairment were defined as those with pure-tone average  $\geq 41$  dBHL in adults and  $\geq 35$  dBHL in children in the better ear, or children under age 4 who failed the OAE test in both ears. Each case with hearing loss was examined by an ear, nose and throat nurse who indicated the main likely cause.

**Results:** We examined 3,567 (86.9%) of 4,104 eligible people. The overall prevalence of hearing impairment was 3.6% (95% confidence interval (CI): 2.8–4.6). The prevalence was low in people aged 0–17 (1.1%, 0.7–1.8%) and 18–49 (1.1%, 0.5–2.6%) and then rose sharply in people aged 50+ (14.8%, 11.7–19.1%). Among cases, the majority were classified as moderate (76%), followed by severe (15%) and profound (9%). More than one third of cases of hearing impairment were classified as unknown (37%) or conductive (37%) causes, while sensorineural causes were less common (26%).

**Conclusions:** Prevalence of hearing impairment is in line with WHO estimate for Sub-Saharan Africa. The majority of cases with known causes are treatable, with impacted wax playing a major role.

**Keywords:** hearing loss; health surveys; Sub-Saharan Africa; Cameroon

## Introduction

There are an estimated 360 million people worldwide with disabling hearing impairment, i.e., average hearing level greater than 40 dB in adults or 30 dB in children in the better ear, of whom the majority live in low- and middle-income countries (LMICs) [1]. Sub-Saharan Africa is estimated to be one of the three WHO regions with the highest prevalence of hearing impairment, and most of the causes are believed to be avoidable or treatable [1]. However, these estimates are based on little data; a recent review found only three population-based studies that measured hearing and 14 school screening surveys for the region [2].

Hearing impairment can impact negatively on oral communication skills and may lead to isolation and discrimination [3]. Among those affected, children are less likely to go to school or do not progress as well as their peers, and adults are more likely to be unemployed or working in a low grade occupation, especially in LMICs [1]. Consequently, hearing loss incurs social and economic costs for the person and the community.

Public health measures can effectively reduce hearing loss or minimise its impact through prevention (e.g., rubella vaccination), treatment (e.g., medical intervention for otitis media) or early diagnosis followed by appropriate interventions (e.g., hearing aids). Few Ear-Nose-Throat (ENT) services are currently available in Africa, and these need to be scaled up [4]. Gathering reliable local information on the extent and main causes of hearing impairment is a crucial step to developing programmes for prevention, identification and management.

We did not find prevalence estimates for hearing impairment in Cameroon. WHO prevalence estimates for disabling hearing impairment was 4.5% for Sub-Saharan Africa region [5]. Previous surveys were conducted in Uganda [6], Madagascar [7] and Nigeria [8], with prevalence estimates for hearing impairment ranging from 18% to 44%. One study was undertaken in Cameroon to identify the causes of early onset (before age 15) severe/profound hearing loss and found that the dominant causes were vaccine preventable infectious diseases (41.3%), genetic (14.8%), or unknown causes (32.6%) [9]. Data were not available for causes of hearing loss acquired in adulthood.

The aim of this study was to estimate the prevalence and causes of hearing impairment across all ages in Fundong Health District, North West Cameroon.

## Methods

### Study population

This study was undertaken during August-October 2013 in Fundong Health District, North West Cameroon as part of a population-based disability survey. The expected prevalence of disabling hearing impairment (i.e., average hearing level  $\geq 41$  dB in adults or  $\geq 35$  dB in children in the better ear) was conservatively estimated to be 4% [2,10]. Estimating this prevalence required a sample of 4,056, assuming precision of 20%, 95% confidence, a design effect of 1.5 and 20% non-response rate.

We used a two-stage sampling procedure. Fifty-one clusters of 80 people were selected using probability proportionate to size sampling. The 2005 census data was used as the sampling frame. Within clusters, households were selected using compact segment sampling [11]. Existing maps were identified or sketch maps showing the approximate distribution of the population were drawn by team members in collaboration with community leaders. These were divided into segments of approximately 80 people and one segment was randomly selected. The enumerators visited all households door-to-door in that segment until 80 people were enumerated.

At the household level, a roster was compiled to record the name, age, sex and contact details of each household member. Household members were informed about the survey and invited to attend a previously identified central location over the next two days. If an eligible person did not attend the central location the enumerators visited their household at least twice to encourage attendance. If they were unable to travel to the central location (e.g., due to mobility impairment) the survey team visited them at their household at the end of the second day.

### Screening for hearing impairment

Initial screening of all participants was undertaken through an otoacoustic emission (OAE) test in both ears. Participants aged 4 years and above who failed this test in both ears or for whom an OAE reading could not be taken (e.g. discomfort) underwent a manual pure-tone audiometry (PTA) screening, using an Interacoustics screening audiometer (model AS608)

with TDH-39 earphones mounted inside circumaural audiocups for extra noise attenuation. The machines were calibrated according to ISO 389-1 and ANSI S3.6 standards. Both tests were conducted in the field in the quietest space available. Environmental noise was measured and recorded on each test using a sound level meter. Hearing thresholds in each ear were measured at 1 kHz, 2 kHz, 4 kHz, 0.5 kHz, and again at 1 kHz to ensure consistency of response, and the pure-tone average for each ear across these four frequencies was recorded. Children under age 4 years underwent OAE testing only as PTA is not feasible for this age group.

Cases of hearing impairment were defined as those with pure-tone average  $\geq 41$  dBHL in adults [12,13] (18+ years) and  $\geq 35$  dBHL in children [10] (4–17 years) in the better ear, or children under age 4 who failed the OAE test in both ears. The degree of hearing impairment was graded based on pure-tone average in the better ear, as follows: "moderate" when 41–60 dBHL (18+ years) or 35–60 dBHL (4–17 years); "severe" when 61–80 dBHL and "profound" when  $\geq 81$  dBHL.

Each person identified as having a hearing impairment was examined by an ENT nurse who indicated the main likely cause based on otoscopy and questions including "How long has the subject had difficulty hearing?" and "Does any relative of the subject have difficulty hearing?". Through the screening and examination questionnaire we classified causes as those related to:

- conductive hearing loss (potentially reversible), e.g. wax, foreign body, otitis externa, otitis media, and perforation of the tympanic membrane;
- sensorineural hearing loss (permanent), e.g. infectious diseases, genetic conditions, and non-infectious conditions;
- unknown cause.

#### Self-reported hearing function

Respondents reported whether they had any difficulty in hearing, using the Washington Group Extended Set on Functioning (ESF) questionnaire. The Washington Group ESF is designed to identify participant's functional limitations in core domains such as seeing, hearing and walking, and with answers given on a four point-scale: "no difficulty", "some difficulty", "a lot of difficulty" and "cannot do at all" [14,15].

## Training

Three survey teams each received 10 days training. ENT nurses received a week of training in diagnoses by an experienced ENT surgeon in the WHO survey tool protocol. Their diagnoses were compared with that of the ENT surgeon. The inter-observer variation for all measurements was assessed to ensure it was of an acceptable standard (i.e. Kappa  $\geq 0.6$ ).

## Data analysis

Data were analysed using STATA (version 12). The "svy" command was used to derive prevalence estimates accounting for the cluster sampling design. Sensitivity, specificity, predictive values positive and negative were estimated comparing clinical measures to self-reported hearing loss. First, using a broader definition of hearing loss (i.e. "some" or more difficulty hearing reported) and then using a more restrictive definition of hearing loss (i.e. "a lot" or more difficulty hearing).

## Ethical approval and consent

Ethical approval was obtained from the National Ethics Committee for Research in Human Health (CNERSH, Cameroon), the Cameroon Baptist Convention Health Board Institutional Review Board and the London School of Hygiene & Tropical Medicine. Referral services available in the region were mapped in advance to ensure appropriate onward referral for any individuals identified with unmet healthcare needs.

All participants were read an information sheet about the study and given the opportunity to ask questions. If they agreed to participate, written/finger print consent was taken. For children under age 21 years a caregiver was required to provide consent and to remain present throughout the screening. Participants who screened positive for hearing impairment were examined by a clinician and referred for ear and hearing care services (as appropriate) and to a Community-based Rehabilitation (CBR) or Self Help Group program for additional support in education, livelihoods, benefits etc.

## Results

### Population and demographics

A total of 4,104 people were enumerated for the population-based survey, of whom 3,567 were screened for hearing impairment, giving a response rate of 86.9%. Amongst non-participants, only 17 (0.4%) refused and 520 (12.7%) were unavailable. Comparing to those examined (mean age 24.4 years), refusers were older (39.4,  $P < 0.001$ ) as were those not available (28.1 years,  $P < 0.001$ ). The groups did not differ by gender (examined: 59.2% female; refusers: 64.7%,  $P = 0.65$ ; not available: 56.0%,  $P = 0.17$ ).

The sample (2013) was compared to a demographic projection based on Cameroon Census 2005 and found to somewhat oversample women, infants (0–9 years) and older groups (60+ years), and to undersample young adults (20–39 years) particularly amongst males (Table 1).

### **[Table 1 here]**

### Hearing screening protocol outcomes

From 3,567 screened, the complete screening protocol was undertaken for 3,353 people (94.0%), 97.6% of people aged 4+ years and 70.7% of children under age 4 years. Incomplete protocols occurred due to environmental noise (e.g., loud rain), discomfort or individual level cognitive difficulties. Participants with incomplete protocols were considered cases or non-cases depending on their outcome patterns (Figure 1). Specifically, since only 8 (2.4%) of 336 children <4 years who underwent the OAE screen failed this test (328 pass and 8 fail), we classified children with incomplete OAE as non-cases for hearing impairment. Conversely, since out of the 297 people aged 4+ years who failed OAE, 90 (30.3%) also failed in PTA, we classified those who had failed OAE but with incomplete PTA as cases. Finally, when both OAE and PTA were incomplete we classified participants as non-cases.

### **[Figure 1 here]**

## Prevalence of hearing impairment

The overall prevalence of hearing impairment was 3.6% (95% confidence interval (CI): 2.8–4.6) (Table 2). The prevalence was low in people aged 0–17 (1.1%, 0.7–1.8%) and 18–49 (1.1%, 0.5–2.6%) and then rose sharply in people aged 50+ (14.8%, 11.7–19.1%). Overall, 74% of cases of hearing impairment were in people aged 50+. There was little difference in the prevalence between men and women.

### **[Table 2 here]**

Among cases, the degree of hearing impairment was assessed for those aged 4+ years who completed the whole protocol (n = 100). The majority were classified as moderate (76%), followed by severe (15%) and profound (9%). The overall prevalence of hearing impairment by severity was 2.5% (1.9–3.2%) for moderate, declining to 0.5% (0.3–0.8%) and 0.3% (0.1–0.6%) for severe and profound degree, respectively, with no statistical difference across gender groups (Table 3).

### **[Table 3 here]**

## Causes of hearing impairment

Overall, the main likely causes of hearing impairment were unknown for 37% of the cases (n = 47), while another 37% (n = 47) were detectable causes related to conductive hearing loss and 26% (n = 33) were causes usually related to sensorineural hearing loss. Within these two groups of causes, impacted wax in the ear canal (31.5% of overall cases, n = 40) and age related hearing loss (22.8%, n = 29) were the most common, respectively. The pattern of likely causes changed across age groups, with the largest proportion corresponding to unknown causes among children and to impacted wax among adults under 50 years of age (Figure 2). Among those aged 50+ years, aging, unknown causes and impacted wax showed similar proportions.

### **[Figure 2 here]**

## Self-reported hearing function versus clinically measured hearing impairment

Prevalence of hearing loss based on self-report was higher than the estimate based on PTA when defined as "some" or more difficult hearing (14.1%) and lower when defined as "a lot" or more difficult hearing (1.1%) (Table 4). The option "cannot do at all" was not reported by any participant/proxy. Sensitivity was 67% and specificity was 88% when comparing clinical measures and a broader definition of self-reported hearing loss (i.e. "some" or more difficulty category) and 22% and 99.6%, respectively, for the more restrictive definition (i.e. "a lot" or more difficulty). Likewise, positive and negative predictive value were estimated as 16% and 99%, and 65% and 97%, respectively, for the broader and more restrictive definition of hearing loss based on self-report.

**[Table 4 here]**

## Discussion

This population-based survey was conducted to estimate the prevalence and likely causes of hearing impairment across all ages in North West Cameroon. The overall prevalence of disabling hearing impairment was 3.6% (95% confidence interval (CI): 2.8–4.6). The prevalence was relatively low at 1.1% among children (<18 years) and adults (18–49 years) and rose rapidly to a level of 14.8% of those people aged 50+, so that the vast majority of cases were in the oldest age group. Hearing impairment was mostly moderate with few cases classified as severe or profound. In about two-fifths of cases we could not identify the main likely cause, but for those cases where we could identify they were mostly related to the external or to the middle ear. Among participants for whom a cause could be detected, impacted wax in the ear canal was the commonest cause, especially among adults (18–49 years). Age related hearing loss was important among people aged 50+. Among children, the unknown causes prevailed.

### Prevalence of hearing impairment

Three previous surveys of hearing impairment were identified for Sub-Saharan Africa [2], all of which included people of all ages. All used lower thresholds for defining hearing impairment than we did, including 30 dBHL in Uganda [6] and Madagascar [7] and 25 dBHL in Nigeria [8]. Coherently, all three surveys reported higher prevalence estimates than found here, ranging from 18% in both Nigeria and Uganda, to 44% in Madagascar. Although we have not fully followed the WHO protocol, our estimate of 3.6% disabling hearing impairment is in line with WHO estimate of 4.5% for Sub-Saharan Africa region [5], which is consistent with the higher cut-offs we adopted. This similarity was yet more evident when comparing WHO estimate of 6.4% disabling hearing impairment among adults (15+ years of age) with our estimate of 6.5% (18+ years of age) (data not shown). Our estimate of 1.1% among children was slightly lower than the WHO estimates (1.9%). However the WHO estimate for children is based on a threshold of 30 dBHL while in our study we adopted a slightly higher threshold (35 dBHL) following the Global Burden of Disease (GBD) expert group definition for hearing impairment [10].

## Causes of hearing impairment

Causes of hearing loss were difficult to determine in this field setting, and consequently 37% of cases were of unknown causes. This concurs with previous prevalence studies, with an average proportion of 35% of unknown causes in Africa [2]. Specifically in Cameroon, a previous study found causes were unknown for 33% of 582 people with early onset (before age 15) severe/profound hearing loss [9].

In this study, where causes could be determined, more than a half was conductive which is potentially reversible by treatment. This is consistent with findings in other settings in Africa [2]. Within these causes, impacted wax was the most common in this population, which can be easily treated or prevented through primary health care services.

Although not all of conductive hearing loss show visible signs via otoscopy (e.g., otosclerosis), it is plausible to suggest that in this study the greater proportion of unknown causes is related to inner ear aetiologies, which cannot be detected via otoscopy. Inner ear lesions lead to a sensorineural, permanent hearing loss, highlighting needs for hearing aids, rehabilitation, educational and social support.

## Self-reported hearing function versus clinically measured hearing impairment

Overall hearing loss based on self-report either overestimated or underestimated the clinical impairment prevalence depending on the degree of difficulty taken as cut-off point. Regardless of the definition, specificity and predictive negative values were high, as expected in low prevalence settings. Accuracy estimates suggest that a self-reported functional approach alone will not identify all individuals with moderate or worse hearing impairment.

There were a number of limitations to the study design that need to be taken into account. The prevalence of hearing impairment was lower than expected, so that the study was potentially under-powered. Using only OAE to screen children under age 4 may have led to incorrect classification of cases/non-cases [16], although OAE accuracy measures for identifying

hearing impairment have shown good performance, including low rates of false positive and false negative results [16,17]. Despite the ENT nurses training in diagnoses, they were made in the field with limited equipment available, which made it difficult to determine the causes reliably, and consequently more than one third of cases were of unknown aetiology. The addition of a tympanometry on site would have helped to better differentiate between conductive and sensorineural hearing loss. The ENT nurse indicated only the main likely cause, however more than one cause can be simultaneously related to a hearing impairment. There were also important strengths. The study was population-based and included people of all ages. Hearing loss was measured using clinical instruments, and a clinician was available in the field to make diagnoses.

The impact of hearing impairment is potentially large on society, individuals affected and their families [1,18]. Hearing loss is the fifth leading cause of years lived with disability according to the GBD Study 2013 [19]. In Cameroon, most cases with known causes could have been prevented or treated, with appropriate referral to a specialist. In cases of permanent hearing loss, hearing aids and rehabilitation can improve communication abilities and enable better quality of life and future achievements in life. However, human resources for health care are poorly available in Cameroon. The national estimate of the health workforce density is 1.3 per thousand population [20]. Indeed, among the WHO regions, Africa stands with the lowest cadres of ear and hearing human resources (ENT specialists, audiologists and speech therapists) with less than one of each per million population where data is available [21]. In LMICs, global initiatives are needed to help build national strategies to prevent hearing impairment and to minimize its adverse effects.

In the context of an overall lack of population-based epidemiological data on hearing impairment and its causes [21], this study adds to the knowledge providing data from a country in one of the most affected and least studied regions - Sub-Saharan Africa. This is an essential step towards developing strategic plans for prevention, identification and management of cases in Cameroon. In the future, new research efforts should address the development of national hearing care infrastructure and human resources.

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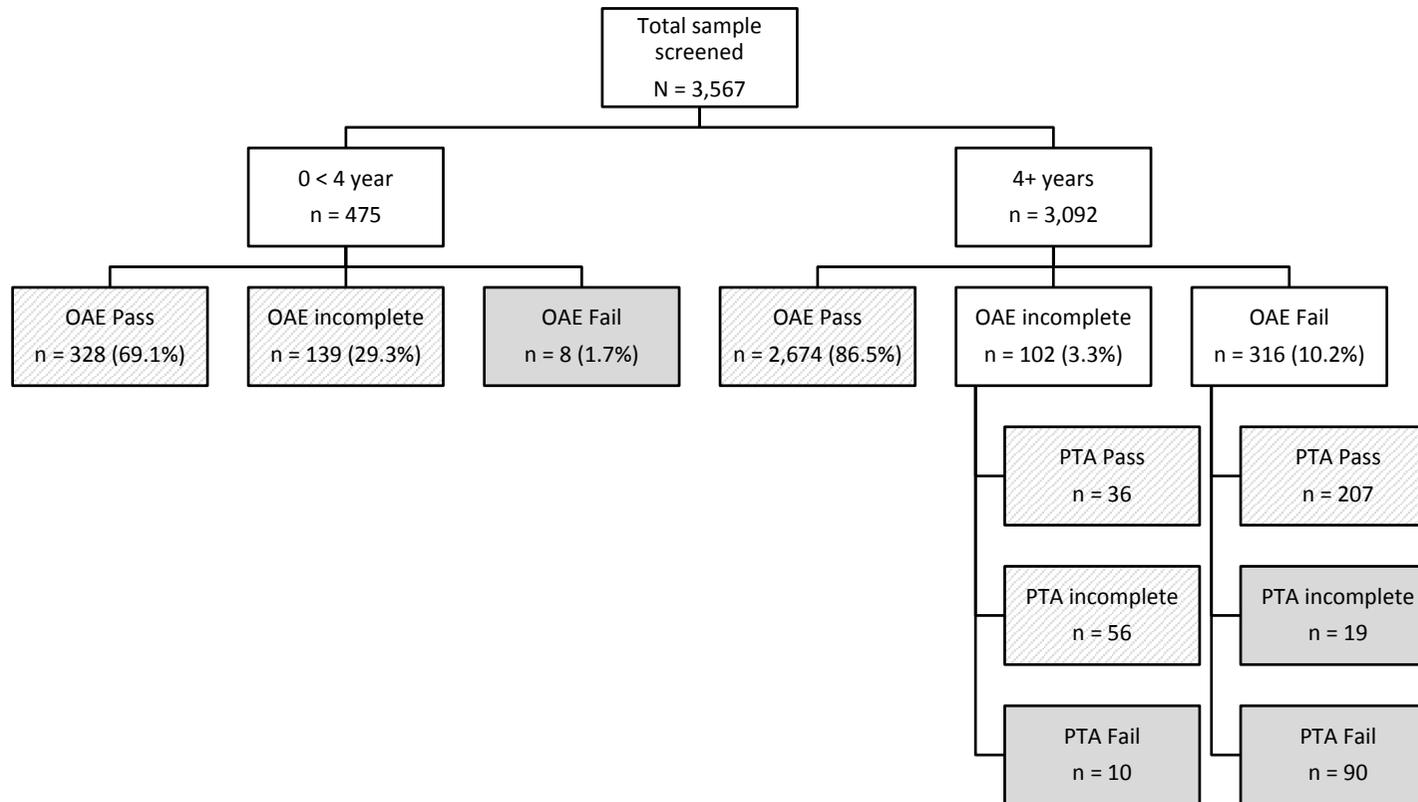
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**Table 1. Age and gender distribution of district<sup>a</sup> and study sample population, Fundong Health District, North West Cameroon, 2013**

Age group (yr)	Men				Women				All			
	District		Study Sample		District		Study Sample		District		Study Sample	
	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
<b>All</b>	<b>909,933</b>	<b>(47.9)</b>	<b>1,455</b>	<b>(40.8)</b>	<b>990,614</b>	<b>(52.1)</b>	<b>2,112</b>	<b>(59.2)</b>	<b>1,900,547</b>	<b>(100.0)</b>	<b>3,567</b>	<b>(100.0)</b>
0-9	285,644	(31.4)	609	(41.9)	279,340	(28.2)	630	(29.8)	564,984	(29.7)	1,239	(34.7)
10-19	258,047	(28.4)	399	(27.4)	257,261	(26.0)	423	(20.0)	515,308	(27.1)	822	(23.0)
20-29	136,854	(15.0)	77	(5.3)	174,712	(17.6)	307	(14.5)	311,566	(16.4)	384	(10.8)
30-39	83,977	(9.2)	70	(4.8)	107,390	(10.8)	197	(9.3)	191,367	(10.1)	267	(7.5)
40-49	55,672	(6.1)	67	(4.6)	70,492	(7.1)	152	(7.2)	126,164	(6.6)	219	(6.1)
50-59	38,749	(4.3)	61	(4.2)	47,397	(4.8)	146	(6.9)	86,146	(4.5)	207	(5.8)
60-69	28,845	(3.2)	60	(4.1)	32,158	(3.2)	127	(6.0)	61,003	(3.2)	187	(5.2)
70-79	15,709	(1.7)	66	(4.5)	14,930	(1.5)	86	(4.1)	30,639	(1.6)	152	(4.3)
80+	6,436	(0.7)	46	(3.2)	6,934	(0.7)	44	(2.1)	13,370	(0.7)	90	(2.5)

<sup>a</sup> Based on Cameroon Census 2005 demographic projection for North West Region, 2014



**Figure 1. Flow chart of hearing screening protocol outcomes, Fundong Health District, North West Cameroon, 2013.** OAE: otoacoustic emission; PTA: pure-tone audiometry screening. Striped boxes indicates non-cases and grey filled boxes indicates cases of hearing impairment for this study.

**Table 2. Prevalence of hearing impairment by age and gender group, Fundong Health District, North West Cameroon, 2013**

	n	Hearing Impairment <sup>a</sup>		
		Cases	Prevalence (%)	95% CI <sup>b</sup>
All	3,567	127	3.6	(3.0, 4.2)
Age group (yr)				
0–17	1,950	22	1.1	(0.7, 1.8)
18–49	981	11	1.1	(0.5, 2.6)
50+	636	94	14.8	(11.7, 19.1)
Gender				
Men	1,455	44	3.0	(2.2, 4.2)
Women	2,112	83	3.9	(2.9, 5.4)

<sup>a</sup> Defined as those with pure-tone average  $\geq 41$  dBHL in adults (18+ years) and  $\geq 35$  dBHL in children (4–17 years) in the better ear, or children under age 4 who failed the otoacoustic emission test in both ears.

<sup>b</sup> All estimates adjusted for sample design.

**Table 3. Prevalence of hearing impairment by severity according to gender group among people aged 4+ years, Fundong Health District, North West Cameroon, 2013**

	n	Degree of Hearing Impairment <sup>a</sup>					
		Moderate		Severe		Profound	
		Cases	P % (95% CI) <sup>b</sup>	Cases	P % (95% CI) <sup>b</sup>	Cases	P % (95% CI) <sup>b</sup>
All	3,092	76	2.5 (1.9, 3.2)	15	0.5 (0.3, 0.8)	9	0.3 (0.1, 0.6)
Gender							
Men	1,238	26	2.1 (1.4, 3.0)	5	0.4 (0.2, 1.0)	2	0.2 (0.04, 0.7)
Women	1,854	50	2.7 (1.9, 3.9)	10	0.5 (0.3, 1.1)	7	0.4 (0.2, 0.9)

P, Prevalence.

<sup>a</sup> Based on pure-tone average in the better ear: moderate when 41–60 dBHL (18+ years) or 35–60 dBHL (4–17 years); severe when 61–80 dBHL and profound when  $\geq 81$  dBHL.

<sup>b</sup> All estimates adjusted for sample design.

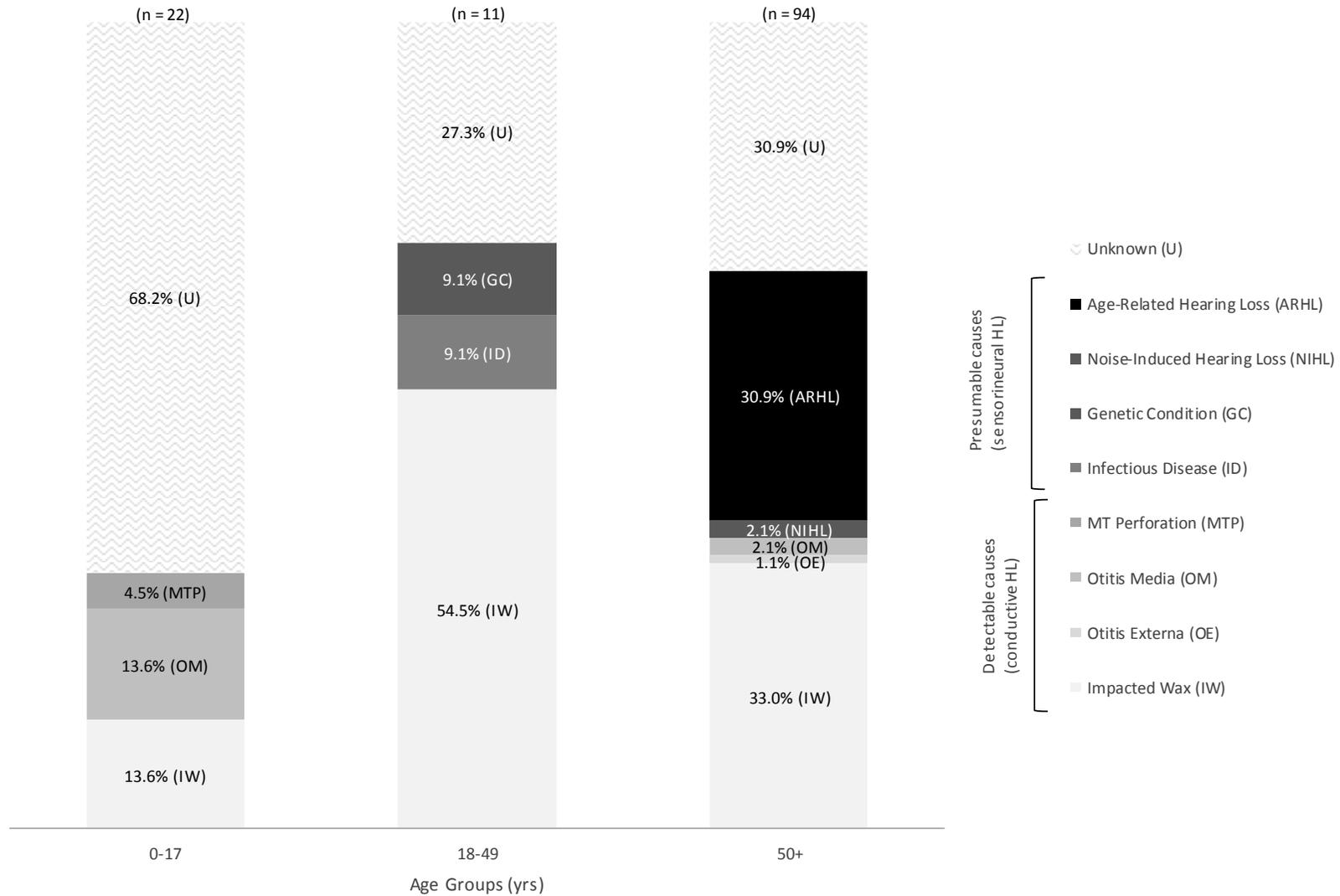


Figure 2. Main likely causes of hearing impairment by age group, Fundong Health District, North West Cameroon, 2013 (n = 127)

**Table 4. Relationship between self-reported hearing function and clinically measured hearing impairment, Fundong Health District, North West Cameroon, 2013**

Degree of hearing impairment based on PTA	n = 3,017 <sup>a</sup>	Do you have difficulty hearing? <sup>b,c,d</sup>		
		None	Some	A lot
No hearing impairment	2,906	2,549 (87.7%)	345 (11.9%)	12 (0.4%)
Moderate	76	32 (42.1%)	34 (44.7%)	10 (13.2%)
Severe	15	1 (6.7%)	8 (53.3%)	6 (40.0%)
Profound	9	0 (0.0%)	3 (33.3%)	6 (66.7%)
Any hearing impairment	100	33 (33.0%)	45 (45.0%)	22 (22.0%)

PTA, pure-tone audiometry.

<sup>a</sup> Considering all participants 4+ years old except 75 with incomplete PTA.

<sup>b</sup> 11 Washington Group responses missing.

<sup>c</sup> Responses from proxy for children.

<sup>d</sup> The option "Cannot do at all" was not reported by any participant/proxy.