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Prevalence of hearing impairment among primary school children in the Kilimanjaro region within Tanzania

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ABSTRACT

Introduction: Hearing impairment is becoming a public health concern and a widespread problem. The World Health Organization estimates that globally there are about 466 million people with hearing impairment, of which 34 million represent children. We examined the prevalence and etiology of hearing impairment among primary school children in the Kilimanjaro region within Tanzania.

Method: A cross-sectional study of primary school children aged 6–17 was conducted to determine the prevalence of hearing impairment. Tanzanian primary school children were screened for hearing loss and an otoscopy was performed on those who failed the screening.

Results: There were 403 children screened from three schools in rural areas of Tanzania. The prevalence of hearing loss was found to be 7.1%, 10.8% and 16.7% in the different schools. Cerumen was proven to be the most common possible cause of hearing impairment. Other possible causes of hearing impairment were found to be (in descending order) otitis (all types), no abnormalities, and perforation of the tympanic membrane.

Conclusions: These results show a need for better identification of hearing impairment in school-going children and implementation of prevention and treatment options in Tanzania and other developing countries. This can further improve children's potential for language development, communication and academic achievement.

1. Introduction

Hearing impairment is becoming a public health concern worldwide. Globally, there are about 466 million people (6.1%) with hearing loss, where approximately 34 million (7%) represent children [1]. In Sub-Saharan areas the prevalence of hearing impairments among children has been estimated to be around 8.6% (i.e. almost 18 million children) [2]. According to the World Health Organization (WHO), 60% of all hearing loss in children in developing countries is due to lack of preventive measures [3].

Any type of hearing loss in children has been shown to have a major impact on speech understanding, language and social development. Impacts like these may lead to problems in academic achievements such as reading difficulties, poor spelling, and writing skills [4]. Martinez and Coursen-Neff [5] state that half of the children with disabilities, including hearing impairments (HI), never begin their education and twice as many drops out during the first years. They may also be stigmatized and have increased risk of violence [6]. Therefore, it may be a problem that many children in developing countries, with a good starting point for learning, are never enrolled or drop out of school due to an impaired hearing ability.

The literature sets different criteria for what is considered "normal hearing". The American Speech-Language-Hearing Association defines hearing loss as hearing thresholds greater than 15 dB Hearing Level (dB HL) [7]. However, the WHO defines normal hearing when the Pure-Tone-Average (PTA) is smaller than 25 dB HL [3]. Laugen [8] discusses how children with mild hearing loss can also experience challenges, even with hearing loss smaller than 25 dB. By using the criteria set by WHO, hearing loss between 16 and 24 dB HL, which the American Speech-Language-Hearing Association includes in its criteria, is excluded. A study conducted in South Africa by Mahomed-Asmail et al. [9] refers to the fact that it is appropriate to set the threshold level for

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hearing screening somewhat higher in developing countries, due to challenging test conditions with regard to background noise. A systematic review analysis of 28 previous studies, with the aim of finding the prevalence and causes of hearing impairment in Africa, indicated the most common cut-off used for hearing impairment to be 25 and 30 dB HL [6].

As an invisible disability, hearing impairment can be hard for teachers to recognize, and therefore making it difficult to provide early intervention and assistance. The field of study of hearing impairment in Tanzania is at its infant stages, therefore only a small number of children have access to hearing screening. Of those identified as hearing impaired, few get the intervention and aid required.

As the hearing of many children in schools in Tanzania go without screening, data regarding HI is difficult to obtain. In 1995 and 1996 two prevalence studies were conducted on school children in Tanzania. Bastos et al. [10] reported that 37% of the urban children and 17.8% of the rural children had hearing loss above 25 dB HL. The year after Minja and Machemba [11] reported a prevalence of 7.7% in children from urban areas and 14.1% in children from rural areas. However, increasing the limit of hearing loss to 30 dB HL reduced the prevalence to 3% in both districts in the study by Bastos et al. [10], and 5.7% in the urban area and only 0.8% in the rural area in the study by Minja and Machemba [11]. In 2016 Mulwafu et al. [6] estimated the prevalence of hearing impairments in Africa based on 28 published studies. They estimated a prevalence of 17% for the total population and 7.7% for children. More recently, in 2018, a study performed on school children in Ghana reported a prevalence of hearing impairments of 11.9% [12]. This indicates that more effort is needed to assess the actual prevalence of hearing impairments in Africa. This can be done by strengthening and further developing existing screening services to identify children with hearing impairments. It also shows the need for further education for teachers, parents and guardians on the topic of HI in school children and audiologic services.

The prevalence of outer and middle ear pathologies has been reported to be higher in developing countries due to inadequate health resources [13]. In a study that mainly dealt with prevalence and causality of hearing loss in Africa, it emerged that the biggest cause of deviation was middle ear effusion, such as otitis media [12]. More than 80% of all children experience some type of middle ear infection during their first three years of life [14]. The reason for this is because children have a straight eustachian tube which makes them prone to ear infections [15]. It is also known that untreated, otitis media may lead to permanent hearing loss [16].

A large self-reporting survey was carried out in Tanzania in 2012 [17]. Based on the answers from the head of the family, hearing disability was reported for 1% of the respondents [17]. This estimate is even lower than WHO's estimate of children with disabling hearing impairments in Sub-Saharan Africa (1.9%) [18].

The primary objective of this study was to determine the prevalence of hearing impairment at 0.5, 1, 2 or 4 kHz in three primary schools in rural areas in Tanzania. Secondarily, an attempt was made to estimate the cause of the identified hearing impairment by examining the participants with otoscopy.

2. Method

The prevalence study presented in this paper was performed in parallel with the testing of a new game-based screening tool. In this paper only the results from the prevalence study are presented. The new game-based screening tool is still under development and will be presented in a later paper.

This study was conducted using a descriptive quantitative cross-sectional design. The data for this study was collected in the period between 3 March and 15 March, 2019. The team was comprised of four students and one associate professor from the Norwegian University of Science and Technology (NTNU), one senior Lecturer in special education from the Open University of Tanzania (OUT), seven teachers from Patandi Teachers College of Special Needs Education in Tanzania, and one ENT physician. Prior to the data collection, the project was reported to the Norwegian Center for Research Data (ref. 58283) and to the National Institute of Medical Research for research in Tanzania (ref. NIMR/HQ/R.8a/Vol.IX/3009) for ethical approval. In all the three schools, the researchers had permission from educational authorities in the district.

The Head of School at each of the three schools were given information about the screening, and they were the one to inform the teachers and children in their respective schools about the study. They also signed the consent on behalf of the parents. This mandate was given by the district education officer. If a child was detected with hearing impairment and needed follow-up, parental consent would be obtained. This procedure was described and accepted in the ethical approval from the National Institute of Medical Research. Participation was \revision{otherwise} voluntary, so only children who consented were included in the study, and they were free to withdraw consent at any given time.

2.1. Study population

403 children participated in the study from three different primary schools in rural areas of Tanzania. The total sample contained 52% boys (n = 209) and 48% girls (n = 194) aged 6–17 years ($M = 8.1$ years, $SD = 1.5$ years). 74 (18.4%) of the participants were reported with albinism.

Albinism is found in populations all over the world, but earlier studies show that the prevalence is higher in Africa, especially in the areas east and south of Sahara, compared to other countries globally. In Tanzania the prevalence of albinism is around 1 in 1400 and an increased prevalence of hearing loss among those with this condition has been reported [19]. Mice with albinism have also been found to have premature age-related and noise-induced hearing loss [20]. In two of the schools, School A and School B, children with albinism were enrolled. All children with albinism in grade 3 to grade 7 were included in this study.

The children were selected using a convenience sampling method. When new participants were needed, the teachers at the respective schools went to the classrooms and selected among the children present. Since the testing was performed during a period of two weeks, and all three schools had to be tested within this time, not all children in all classes were tested. The goal was to screen as many children as possible within the available time slot for each school. School A was measured during three days, School B five days, and School C two days. The differences in time were a result of the availability of personnel at each school.

2.2. Hearing screening

By using an audiometer, an exact intensity and frequency are presented to the subjects. This provides information on the amount of intensity required for the person to hear the different tones at each frequency. This study used sine tones for the hearing screening. If a hearing loss is detected, further examination of the hearing and location of the hearing loss is needed [21].

The hearing assessments in this study consisted of having two audiometric stations in a classroom – each equipped with two manual battery-driven audiometer (Micromate 304, Otometrics) and headphones (Sennheiser HDA 200 and Radioear DD450). The two test subjects being assessed simultaneously were facing away from each other, thus excluding the possibility of visual disturbance.

In this study normal hearing was defined as hearing thresholds up to 25 dB HL. This means that all the children that had hearing loss above 25 dB HL were followed up with an otoscopy and if necessary further referral to an ENT physician. The prevalence of hearing loss using a

30 dB HL limit is also presented in the results to make it easier to compare the numbers with other studies using this limit.

2.3. Procedure

The hearing assessments were based on the international standard ISO 8253-1 [22]. The signal intensity was first presented to the test subjects at a level of 40 dB HL. If the test subject responded to this level of intensity, the intensity got decremented to 20 dB HL, which was the lowest intensity presented. If the test subject then responded to this level of intensity twice it was recorded as the threshold at the tested frequency. However, if the test subject did not respond the modified Hughson-Westlake procedure was used to determine the hearing threshold [23]. The lowest level of intensity of which the test subject responded a minimum of three times was then recorded as threshold. The audiometric equipment was pre-calibrated to have a maximum limit of 80 dB HL. Intensity levels above 80 dB HL were not measured during the data collection.

A response button was initially used to collect the child's response to audible signal. This method was incidentally seen to be an inappropriate method for some of the children. It was observed that the technical appearance of the response button could be a distraction, and some of the children had difficulties understanding how or when to press the button. Therefore, it became time consuming to achieve reliable results. Hand raising as an alternative method for response was shown to be a more reliable response than the button, and this method was then used throughout the data collection process.

According to ISO-8253-1 [22], all instructions were given individually to the participants in their own language. Prior to the assessment, instructions and demonstrations were given to the children by the teachers from Patandi Teachers College of Special Needs Education. The instructions contained information about how the test would be performed, e.g. placement of the headphones, and how they should respond when they heard a sound.

2.4. Otoscopy

Otoscopic examination was done in order to exclude any potential abnormalities in the outer and middle ear [16] for participants that did not pass the audiometric screening assessment. All the participants that were documented with hearing loss were further registered in a document which was given to the respective Head of School for further follow-up. The document contained information about the individual child's hearing loss as well as any relevant findings from the otoscopic examination. On the days when the ENT physician was available, he also did further examination immediately after the children had been detected to determine if they needed further follow-up.

2.5. Background noise monitoring

As mentioned before, the audiometric testing was performed in parallel with the testing of a new game-based hearing screening tool. The background noise level was monitored in the room where the game-based screening tool was tested. Since this tool uses an automatic hearing test procedure, it is assumed that the background noise is a larger problem than for the manual audiometry. By using manual audiometers, it is possible to pause the assessment if any disturbing background noise occurs. Nonetheless, the rooms were located near each other, so the background noise level is expected to be similar in both. The monitoring was performed using a Larson-Davis Spark™ 706 dosimeter.

Additionally, a smart phone (Sony Experia XZs) with the AudioTool application (v8.3) was used to measure the frequency spectrum of the background noise.

2.6. Statistical analysis

A statistical analysis was performed to assess the effect of the predictive variables. A binomial dependent variable was constructed for each subject based on their hearing levels. If any of the test frequencies were above 25 dB HL they were categorized as "hearing impaired". The predictive variables used in the analysis were the gender and age of the subjects, the school they were in, and if they were persons with albinisms. The analysis was performed in R [24] using RStudio [25], using a logistic regression model with logit link function. A significance level of 0.05 was used to determine if any of the predictive variables had significant effect on the hearing status.

The prevalence of hearing loss was calculated with 95% confidence intervals using the method suggested by Newcombe and Altman [26].

3. Results

A likelihood ratio test was performed on models adding one predictive variable at a time to determine if any of the factors had significant effect on the dependent variable. Only the schools turned out to have any statistically significance ($\chi^2(2) = 6.7623$, $p = 0.034$). Further, a model with only the schools as predictive variables were constructed to see which of the schools that differed. The results were, however, not evident enough to reject the null hypothesis for any of the schools by themselves. Nonetheless, since the model indicated that the schools differed, the results below are presented school-wise.

In Table 1 the results are presented for each school. The prevalence of children with hearing levels above 25 dB HL, together with the 95% confidence intervals, are presented in Fig. 1. In the table and figure the number of children with hearing level above 30 dB HL is also included. One should notice that the numbers of children with the different abnormalities are based on the measurements using 25 dB HL as limit.

Table 1
Summary of results for each school.

School C	Number of children tested		102	100.0%
	Gender	Female	58	56.9%
		Male	44	43.1%
	Average age (yr.)		8.6 ± 0.5	
	Hearing Threshold			
		HL > 25	11	10.8%
		HL > 30	3	2.9%
	Possible cause of hearing loss			
		Cerumen	5	45.5%
		Otitis (all types)	5	45.5%
		Perforation	0	0.0%
		No abnormalities	3	27.3%
School B	Number of children tested		169	100.0%
	Gender	Female	82	48.5%
		Male	87	51.5%
	Average age (yr.)		7.2 ± 1.7	
	Hearing Threshold			
		HL > 25	12	7.1%
		HL > 30	6	3.6%
	Possible cause of hearing loss			
		Cerumen	11	91.7%
		Otitis (all types)	4	33.3%
		Perforation	0	0.0%
		No abnormalities	1	8.3%
School A	Number of children tested		132	100.0%
	Gender	Female	54	40.9%
		Male	78	59.1%
	Average age (yr.)		8.9 ± 1.1	
	Hearing Threshold			
		HL > 25	22	16.7%
		HL > 30	13	9.8%
	Possible cause of hearing loss			
		Cerumen	10	45.5%
		Otitis (all types)	5	22.7%
		Perforation	2	9.1%
		No abnormalities	6	27.3%

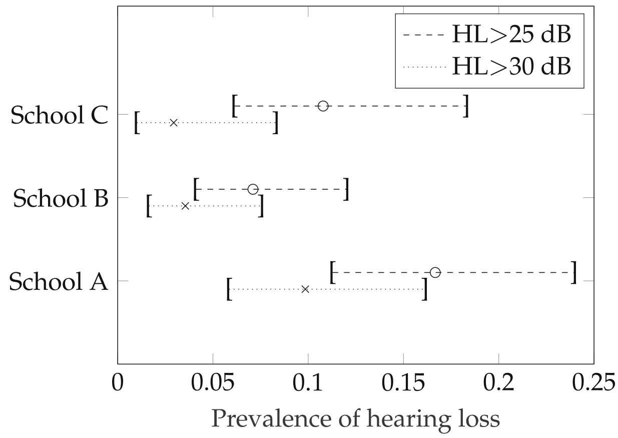

Fig. 1. The prevalence of hearing impairments at the three different schools. The circles and x's indicate the expectation values, and the dashed and dotted lines indicate the 95% confidence intervals.

3.1. Hearing screening test

As can be seen in Table 1 the prevalence of hearing impairments, when using 25 dB HL as limit, were 16.7% at School A, 7.1% at School B, and 10.8% at School C. Increasing the hearing loss limit to 30 dB HL reduces the prevalence to 9.8%, 3.6%, and 2.9%. This shows that especially for School C most of the children had relatively small hearing threshold shifts.

As mentioned earlier, children with albinism were included in this study. The total number of children with albinism were 74 (49 from School A, and 25 from School B). There was, however, no significant correlation found between hearing loss and albinism as a diagnosis ($\chi^2(1) = 0.7258$, NS). The children with albinism are therefore included in the total number of children from each school.

3.2. Otoscopy

The total number of children found with hearing loss (A: $n = 22$, B: $n = 12$, C: $n = 11$) during the audiometric screening were examined further with otoscopy. The results from the otoscopic examination show various causes of hearing loss, but the one that appeared most frequently was earwax (cerumen) or wax plugs (cerumen obturans) followed by otitis (either being otitis media, otitis externa and otitis media with effusion), no abnormalities and perforation of the tympanic membrane. Some of the participants had abnormalities in the right and left ear canal and was therefore recorded as two different conditions in the study.

3.3. Background noise level

The distribution of the measured background noise levels is presented in Fig. 2. An ANOVA was conducted, not assuming equal variance, to see if there was an effect of noise between the schools. The results showed a highly significant effect ($F(2,65) = 9.1,\ p < 0.001$). A post-hoc Tukey test showed that School A ($M = 46.3$, $SD = 5.5$) differed significantly from School B ($M = 51.9$, $SD = 4.5$) and School C ($M = 52.4$, $SD = 5.6$). There was no significant difference between School B and C.

The minimum and maximum levels measured were 38.7 dBA and 65.0 dBA for School A, 44.1 dBA and 71.1 dBA for School B, and 42.1 dBA and 62.4 dBA for School C.

In ISO 8253-1 [22] there are given requirements to the background noise level when performing air conduction audiometry. The limits are given as one-third octave band values for different test frequency ranges. Fig. 3 shows the noise limit used in this study, together with the frequency spectrum of two random, but representative, measurement of

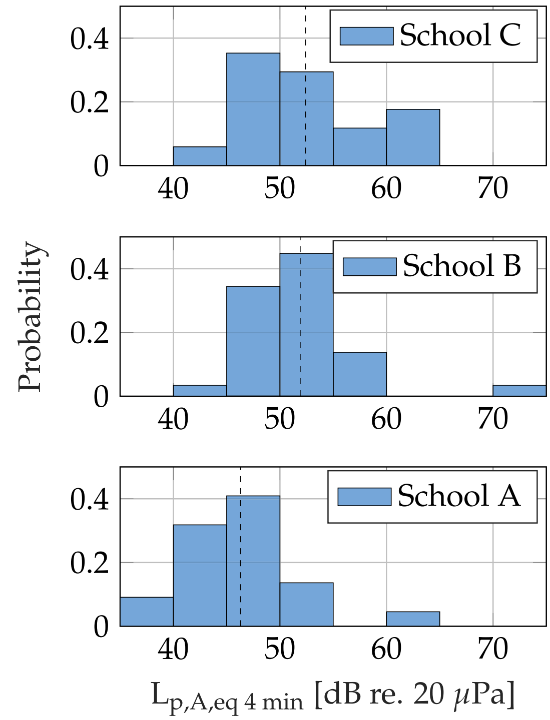

Fig. 2. Distribution of the background noise levels in the different schools. The noise levels are equivalent levels averaged over 5 min. The dashed lines indicate the mean values, 52.4 dB, 51.9 dB and 46.3 dB from top to bottom.

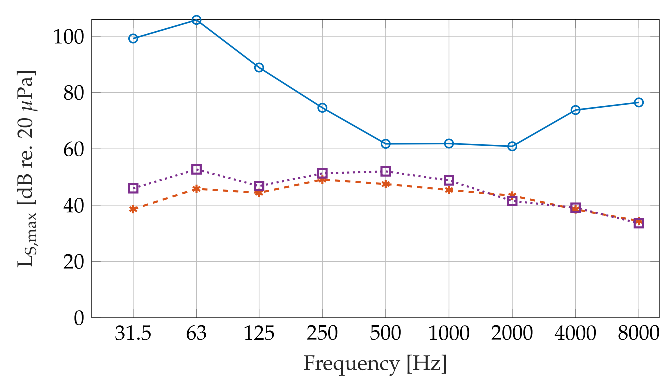

Fig. 3. Frequency spectrum of two random measurements of the background noise. The solid line represents the noise limit we used in the study. The numbers are calculated from the requirements in ISO 8253-1 [22], adding 20 dB since this was the lowest hearing level tested, and adjusting for using circumaural headphones (Sennheiser HDA200 and RadioEar DD450).

the background noise at two of the schools. The measurements were performed using a smart phone; hence the results should be assessed critically. Nonetheless, it gives an indication of the frequency distribution of the background noise. The total sound pressure level of the measurements were 54.5 dBA and 58.2 dBA. One should also notice that the one-third octave band values from the ISO standard have been re-calculated to full octave band levels.

From the figure it is possible to see that the background noise is relatively evenly spread out over the entire frequency range, and that there is a margin of approx. 10 dB to the requirements in the ISO standard. Since most of the background noise levels are around or below the sound levels shown in the random examples, it is assumed that the background noise did not influence the measurements in a detrimental way.

4. Discussion

The study presents findings from hearing assessments conducted from school children in three primary schools in Tanzania. The main focus of the study was the demographic pattern, prevalence and different causes of HI.

4.1. Prevalence of hearing impairment

In this study, a prevalence of hearing impairment of 16.7% from School A, 7.1% from School B, and 10.7% from School C was reported. On account of not having access to implement bone-conducted audiometry, the cause of hearing loss was only an indication based on the results from audiometry, otoscopic examination and consultation with the individual test subjects. Similar data were found in Tanzania in the 1990's. Bastos et al. [10] reported a prevalence of 17% in rural areas, while Minja and Machemba [11] reported 14.1%. Other studies in Africa have also reported similar numbers [12,33], although smaller prevalences have also been reported [27–29].

The prevalence of hearing loss decreases by changing hearing impairment cut-off from 25 dB HL to 30 dB HL. Prevalence of hearing impairment decreases to 9.8% in school A, 7.3% in school B and 2.9% in school C. This corresponds well with the studies from the 1990's but is higher than WHO's estimate (1.9%). The difference to WHO's estimate might be explained by the fact that WHO uses PTA > 30 dB HL instead of single frequencies.

Further, compared to the self-reported survey conducted in Tanzania, which reported hearing impairment in only 1% of the population [17], our findings are much higher. For a child with hearing impairment, parental knowledge and mindset is essential for early detection and intervention programs to be successful. In developing countries, it is especially important, since there are raised concerns of cultural-based ignorance and opposition or refusal towards childhood disabilities. A study from 2009 examined parental knowledge of infant hearing loss, superstitious cultural beliefs, and attitude towards early detection and intervention. The results showed that at least one superstitious cultural belief regarding a possible cause of hearing loss was held by 57% [30]. This may indicate that parents may experience stigma around having a child with a hearing impairment, potentially causing parents not to report the child as hearing impaired in self-reported surveys. This can further indicate that the reported 1% of hearing impairment is evidence of under-reporting.

Access to medical services may be greater for urban children than rural children, thus placing urban children at a lower risk of developing hearing impairment [27]. The assessments in this study were conducted in rural areas, which may explain the high prevalence reported.

We did not find any effect of albinism on hearing impairments. This is not consistent with previous findings from 2009, where researcher found hearing impairment within 51.6% of the participants with albinism, compared to 22.2% within the control group without albinism [19]. The reason for the low prevalence found in this study might be because the premature hearing loss described in the literature has yet not had its onset [20].

The audiometric screening was performed in classrooms at the three different primary schools. The measurements obtained in these classrooms cannot be considered to be as reliable as measurements obtained in a soundproof testing booth which is the optimal environment for the assessment. The noise measurements registered ambient noise levels between 38.7 dBA and 71.1 dBA. Nevertheless, School A had the highest prevalence of hearing impairment and the lowest reported mean level of background noise. Also, School B had the lowest prevalence of hearing loss, but the highest measured noise levels. The levels of background noise therefore indicate that there was no correlation between the increased prevalence and level of background noise. This is not surprising since the researchers performing the tests were experienced audiometrists and could hold back or re-test a given intensity level if the background noise was high at some point.

The headphones used in this study (Sennheiser HDA 200, and Radioear DD450) may not attenuate optimally, especially for the youngest children. Incorrect headphone placement can create a threshold shift up to 30–35 dB HL [21].

4.2. Selection of participants

At School C some of the children in the selection were reported to be low performing students. All children gave reliable responses on the audiometric screening, but it is plausible that hearing impairments might be one of the causes for the low academic performance. In addition, this school is located somewhat more in the countryside, with no electricity and with poor hygiene compared to School A and B. These factors might have played a part in causing the high prevalence of HI at School C.

4.3. Causes of hearing loss

The children who failed the hearing screening were further examined with otoscopy and noted in a report to the Head of School. Even if the otoscopy cannot reveal the true cause of the hearing loss, it may indicate whether the individual child's hearing loss was due to a conductive component or not.

The most common observation in this study was cerumen or cerumen obturans. The prevalence of having cerumen was found to be 45.5% in School A, 91.7% in School B, and 45.5% in School C. Since obstruction of the ear canal can lead to a conductive hearing loss without any underlying condition, removal of the cerumen could have improved the hearing of many of the children. This was not possible within the work of this study, but the children were reported to the Head of School for further follow-up.

Especially School B had a high prevalence of cerumen among the children with hearing loss. The reason is not obvious, but schools are an arena for infections and other diseases [31]. During the data collection in Tanzania, inequalities in terms of hygiene and living conditions were observed between the three different schools. This included access to clean water and having the option to clean themselves and may have affected the prevalence of pathologies in the outer and middle ear. To prevent the spread of infection during the data collection in this study, the headphones were treated with antibacterial between each participant.

In 1996 cerumen impaction was found in 20.4% of all the school children in a rural area of Dar es Salaam in Tanzania [11]. Earlier studies have included cerumen as an etiology for conductive hearing loss, which likely led to higher reported rates of hearing loss [29]. In this study, cerumen was not removed, and the participants did not undergo any further hearing assessments but were instead referred to the Head of School for further follow-up. In the case of this having been done, one could check if cerumen was the true cause of hearing impairment for the individual subject or not. It can be assumed that for many of the children the cerumen was the cause of the hearing loss, hence removal would improve their situation.

The second most common cause of conductive hearing loss recorded in this study was otitis. One should be aware that our findings are only indicative since otitis cannot be stated without a more thorough test. Disregarding this, our findings show a prevalence among those with hearing impairments at each school of 22.7% (five children) at School A, 33.3% (four children) at School B, and 45.5% (five children) at School C. This is consistent with other findings, for instance a study from 2018 that found that the biggest cause of deviation in Africa was middle ear effusion, such as otitis media [12]. Untreated, otitis media may lead to permanent hearing loss [16].

The prevalence of hearing loss and middle ear diseases can be associated with different factors, e.g. economic status and access to information about hygienic routines and methods of treatment for infections. It will therefore be necessary, with good hygiene routines, to prevent the risk of further infections. The prevalence of chronic suppurative otitis media has previously been reported to be 9.4% among rural school children and 1.3% among urban school children [11]. The low prevalence of chronic suppurative otitis media among urban school children is ascribed to better medical services which facilitate early diagnosis and treatment of acute otitis media [11]. Bastos et al. [10] found a correlation between chronic otitis media and living conditions where this condition was found to be more common among children in rural areas compared to children living in more urban areas.

Perforated tympanic membrane was only found in School A where two children had this condition. It was difficult to determine the cause of the perforation, but in general typical causes are mechanical contact with the tympanic membrane or a protracted otitis. During the stay in Tanzania the researchers were told that at this school some of the children used long fingernails or small sticks to scratch inside their ears. Therefore, a hypothesis is that mechanical contact can be a reasonable cause of the perforations found. This also indicates that education about the ear is needed to prevent children from causing harm to themselves.

The otoscopy showed no abnormalities in 27.3% of the children (three) from School A, 8.3% of the children (one) from School B, and 27.3% of the children (six) from School C. These findings may be an indication of a sensorineural hearing loss.

WHO estimates that 60% of hearing impairments are preventable [1]. This is consistent with our study as the causes for conductive hearing loss listed above can be prevented or treated with adequate access to health care. WHO suggests that with increased health education, including screening for early recognition of hearing loss, promotion of personal hygiene and better living conditions could help minimize the risk of developing a hearing impairment [32].

5. Conclusion

This study reported a high prevalence (from 7.1% to 16.7%) of hearing loss based on hearing assessments in three schools. Even if there are uncertainties connected to these numbers, they indicate that hearing loss is not uncommon among school going children in rural areas of Tanzania. The findings are also consistent with other studies, although previous findings show large variations. It was also concluded from the study that the most common cause of hearing impairment was earwax or otitis. These are conditions that can easily be treated or prevented with adequate access to health care. This also shows that it is important to perform hearing screening to identify these children, and to educate both teachers, parents, and the children such that unnecessary damage, stigma, and school drop-out can be prevented. As many children in schools in Tanzania go without screening, data regarding hearing impairment is difficult to obtain, which may indicate that several cases of hearing impairment go unrecorded and therefore untreated.

These results show a need for better identification of hearing impairment in school going children and implementation of prevention and treatment options in Tanzania. This can further improve children's potential for social interaction, academic achievement, which may ultimately lead to improved work opportunities.

Funding

The fieldwork in this study was carried out in collaboration with SINTEF's project “I Hear You”. “I Hear You” is a tablet-based application that is still under development in a project funded by the Research Council of Norway. The application is a game-based hearing screening tool that is supposed to be self-explanatory and not need experienced personnel to be used. The audiometric screening results presented in this paper were conducted in parallel with a test of the game-based screening tool. Children were tested with both methods to assess the sensitivity and specificity of the tool. The screening tool will be presented in a later paper.

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Declaration of competing interest

There are no conflicts of interest.

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