Hearing loss in preschool children from a low income South African community

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Conflicts of interest

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Abstract

Objective: This study aimed to determine and describe hearing loss among preschool children in a South African community representative of typical low- and middle income countries (LMIC).

Method: Children between the ages of 3-6 years received a hearing screening at their early childhood development (ECD) center. If a child failed the hearing screening, he/she was seen for a follow-up rescreen and diagnostic assessment if necessary at their ECD center or closest referral clinic. Diagnostic testing consisted of otoscopy, tympanommetry and pure-tone diagnostic audiometry.

Results: A total of 6424 children were screened at ECD centers with a referral rate of 24.9%. Follow-up assessments were conducted on 45.3% (725) of these children. Diagnostic testing revealed that 9.3% of children presented with impacted cerumen and 18.7% presented with a hearing loss (56.5% binaural). Binary logistic regression revealed no gender or age effects ($p>0.05$). Conductive hearing loss (65.2%) was the most common type of hearing loss found in children.

Conclusions: Most preschool children who failed the hearing screening and received a diagnostic assessment were in need of intervention services for conductive hearing losses, followed by sensorineural and mixed losses.

Keywords

Hearing loss, preschool children, low- and middle- income countries (LMICs), early childhood development (ECD).

1. Introduction

Hearing loss is the most prevalent disabling condition globally [1]. According to the World Health Organization (WHO) [2], 466 million people globally are affected by disabling hearing loss (>40 dB HL), with 34 million of these being children. Disabling hearing loss in children constitutes a barrier to their optimal development of speech, language and cognitive skills, resulting in poor literacy and difficulty progressing in school [3,4]. This in turn has detrimental socio-economic consequences, particularly in low-income and middle-income countries (LMICs) where more than 80% of people with hearing loss live [4].

Newborn hearing screening (NHS) programs have been recommended for the early identification of children affected by hearing loss. However, such programs are still not mandated by hospitals in LMICs, such as in sub-Saharan Africa, where national health systems are too weak to bear the added burden of non-fatal but disabling disorders [5,6]. Even if children were screened at birth, a large proportion of hearing loss presents as delayed-onset hearing loss [7]. Additionally, approximately 35% of preschoolers will have repeated episodes of ear infection that almost always cause temporary hearing loss [8]. Therefore, regular hearing screenings throughout early childhood is necessary [9–11].

Early childhood development (ECD) centres are aimed at providing emotional, cognitive and physical development of children from birth to school going age [12]. These ECD centers have the potential to serve as the first point of access to preventative hearing health care to children who were not screened at birth, or who later acquired a childhood hearing loss, prior to school entry [12,13]. Determining the prevalence of hearing loss in this population is an important step to ensure adequate planning and successful implementation of hearing care in such ECD centers. A number of studies have already reported varying prevalence rates of hearing loss among school children within LMICs. These figures ranged from as low as 1.4% in China [7], 1.75% in Southwestern Saudi Arabia [14] and 2.2% in South Africa [15], to as high as 11.9% in India [16] and 20.9% in Egypt [17].

Varying prevalence rates in preschool children were also reported in sub-Saharan Africa, within Zimbabwe (2.4%)[18] and Nigeria (21.3%) [19]. The main causes for the high rate reported by Adebola et al. (2013) was the presence of otitis media (13.9%) and impacted cerumen (21.8%). High incidence rates of otitis media during the first five years of life have been found to be greatest within sub-Saharan Africa and South-Asia [20]. Biagio, Swanepoel, Laurent and Lundberg [21] indicated a high prevalence of 16.5% for children attending South African primary healthcare clinics, with a higher prevalence in younger (31.4%) than in older children (16.7%).

Whilst a number of studies have reported on the prevalence of hearing loss, evidence on the characteristics and causes of hearing impairment across Africa is very limited [4,22,23]. Methods of determining hearing loss also vary across existing studies with some basing it on a screen result only, whilst others require diagnostic confirmation. This makes it difficult to compare prevalence data across studies, limiting the utility for improving service delivery [22]. Furthermore, research conducted within the South African context often focuses on the school-aged population rather than more-difficult to test preschool-aged children. Determining the occurrence and profile of hearing loss in this population is an important step to ensure informed planning and implementation of early childhood screening programs to promote school-readiness. The present study aimed to determine and describe hearing loss among preschool children (3-6 years) in a South African community representative of typical LMIC contexts.

2. Method

2.1. Context

This study was conducted in the community of Mamelodi, City of Tshwane, Gauteng, South Africa. Census indicates 110 703 households within the community of which only 61% are formal dwellings [24]. The unofficial population of Mamelodi is currently estimated close to one million [24].

2.2. Study population

Hearing screenings were offered to two hundred and fifty ECD centers within the community of Mamelodi East and West. ECD centers (crèches) included both public and private facilities that provided learning and support to children between the ages of three to six years. This was the first screening opportunity for majority of these children due to a lack of NHS services available in the public health care system [5,6]. If consent was obtained, these children received a hearing screening after which they were referred to their nearest clinic for a diagnostic assessment if necessary. Diagnostic assessments were also conducted on children aged seven years because they were six years of age at the time of screening.

2.3. Data collection

2.3.1. Screening phase

Five community healthcare workers (CHWs) were trained to conduct hearing screenings within ECD centers. If consent was obtained from the ECD center and the child's parent/guardian, hearing screening was conducted using the hearScreen^{TM} smartphone application (hearX group, Pretoria, South Africa) operated on Samsung J2 Galaxy smartphones (Andriod OS, 5.1). Smartphones were connected to supra-aural Sennheiser HD280 Pro headphones (Sennheiser, Wedemark, Germany) and calibrated according to prescribed standards (ISO 389-1:1998). A sweep was performed at the test frequencies of 1, 2 and 4 kHz bilaterally at a screening intensity of 25 dB HL. Failure to respond at any frequency in any ear constituted an initial fail. In such cases, children were reconditioned and an immediate rescreen was initiated. If a child referred the immediate rescreen at the ECD center by the same criteria, he/she was referred to their local clinic for a follow-up diagnostic assessment. This was done by automatically sending a text message notification to parents via the mHealth Studio (hearX group, Pretoria, South Africa) cloud-based server.

2.3.2. Diagnostic phase

The first author or a qualified audiologist based at the local clinics initially rescreened children who attended their follow-up appointment using the hearScreen™ smartphone application. This was done to reduce false positive results and minimize the need for unnecessary diagnostic assessments at the clinics where resources and time are limited. A number of children were also seen for follow-up assessments at their ECD center, rather than at the clinic, in order to improve follow-up rates. These children also received a second screen before determining if diagnostic assessment was necessary.

Children who received a diagnostic assessment underwent the following assessments. The external ear canal and tympanic membrane were examined using a handheld Welch Allyn (Welch Allyn, South Africa (Pty)(Ltd.) or Heine mini 3000 (Heine, Germany) otoscope. Any abnormalities were noted. If equipment was available at the clinic, tympanometry was conducted to determine middle ear status using the GSI Auto Tymp (Grayson Stadler, Eden Prairie, USA) or an Interacoustics Impedance Audiometer AT 235 (William Demant, Smørum, Denmark). Results were recorded in terms of middle ear pressure, static compliance and ear canal volume and classified based on the modified Jerger classification [25]. Diagnostic audiometry was performed using either a KUDUwave (eMoyo, Johannesburg, South Africa) Type 2 Clinical Audiometer (IEC 60645-1/2) or the hearTest™ smartphone application (hearX group, Pretoria, South Africa) operated on Samsung J2 Galaxy smartphones (Andriod OS, 5.1). Diagnostic air- and bone- conduction audiometry was determined across 0.5, 1, 2 and 4 kHz. Testing began at 1000 Hz in the left ear at 40 dB HL. Thresholds were obtained using the routine 10 dB descending and 5 dB ascending method (Hughson-Westlake method) and was only conducted down to 15 dB HL. Testing below 15 dB HL was not attempted due to environmental noise, and since the hearing of children is considered normal if all thresholds are at/or below 15 dB HL [26,27]. Both audiometers actively monitored noise levels throughout the test procedure thereby guiding the audiologist to minimize exceeded maximum permissible ambient noise levels.

2.4. Data analysis

Data were analyzed using SPSS v25 (Chicago, Illinois). Descriptive statistical measures were used to analyze screening results, tympanometric findings, diagnostic results and otological status. Binomial logistic regression analysis was performed to determine the effects of age and gender on the prevalence of hearing loss, with $p<0.05$ used to indicate a significant effect.

3. Results

A total of 6424 children between the ages of 3-6 years were screened at ECD centers over a period of 12 months, with an initial referral rate of 24.9% (1602 children). Follow-up assessments were conducted on 45.3% (725) of these children at their ECD center (330 children) or closest referral clinic (395 children). During follow-up assessments these children received a second screening and immediate diagnostic assessment when necessary.

Table 1. Outer and middle ear functioning of children followed-up at clinics/ECD centers

Otoscopy (n=270)	**% Right (n)**	**% Left (n)**
Normal	82.6(223)	84.4(228)
Excessive Cerumen	4.1(11)	4.1(11)
Impacted Cerumen	8.5(23)	8.1(22)
Red Tympanic Membrane/ Fluid	4.8(13)	3.3(9)
Tympanometry (n=224)	**% Right (n)**	**% Left (n)**
Type A	83.9(188)	84.4(189)
Type B	14.3(32)	12.9(29)
Type C	1.8(4)	2.7(6)

A total of 270 children (66.7% female) were seen for a diagnostic hearing assessment, of which 143 and 127 children were tested at clinics and ECD centers respectively. Impacted and excessive cerumen were the most common otoscopic findings after normal ear canal and tympanic membrane findings (Table 1). Of these children, 25 (9.3%) that presented with impacted cerumen (7 unilateral; 18 bilateral) were excluded from data analysis, as they could not be tested diagnostically due to limited resources and time constraints. These children were referred for management. Additionally, 16 children (5.9%) were excluded due to inconsistent responses or the presence of excessive noise.

Data analysis was consequently conducted on the diagnostic results of 245 children. Hearing loss was present in 18.7% (46/245) of children. Table 2 displays the distribution of hearing loss according to gender and age. Binary logistic regression revealed no gender or age effects (p>0.05).

Table 2. Distribution of participant group and those with hearing loss according to age and gender in children tested diagnostically (n=245)

	% Distribution of participants (n)	**% Children with hearing loss (n)**
Gender		
Female	65.7 (161)	16.1 (26)
Male	34.3 (84)	23.8 (20)
Age groups		
3 years	4.1 (10)	10 (1)
4 years	18.0 (44)	13.6 (6)
5 years	22.0 (54)	24.1 (13)
6 years	39.6 (97)	18.6 (18)
7 years	16.3 (40)	20.0 (8)

Bone conduction audiometry, and tympanometry when available, were conducted to distinguish between conductive, sensorineural and mixed hearing losses. An air-bone gap, of 10dB or more, had to be present at two frequencies or more to qualify as a conductive loss. Tympanometry was not conducted on 46 participants (17.0%) due to a lack of equipment at the clinics. Conductive hearing loss (65.2%) was the most common type of hearing loss found in children followed by sensorineural (28.2%) and mixed (6.5%) hearing loss (Table 3). Of the children who presented with conductive hearing losses, 27 presented with a Type B tympanogram, 10 presented with a Type C tympanogram, and 11 ears presented with type A tympanograms (Table 1).

Table 3. Characteristics of hearing loss across participants (n=46)

Characteristics	**% (n)**
Type of HL	
Bilateral conductive	32.6(15)
Unilateral conductive	32.6(15)
Bilateral sensorineural	24.0(11)
Unilateral sensorineural	4.3(2)
Unilateral mixed	6.5(3)
Degree of HL according to the worst ear	
Inconsistent/Not tested	8.7(4)
Mild	54.3(25)
Mild to moderate	10.9(5)
Moderate	10.9(5)
Moderate to severe	8.7(4)
Severe	2.2(1)
Mild to severe	4.3(2)

4. Discussion

A hearing loss was identified in 18.7% of the 245 preschool children who were seen for a diagnostic assessment from the screening program. Unfortunately, this does not reflect a true prevalence rate amongst this population since less than half of the children (45.3%) who referred on their initial hearing screening were seen for follow-up testing. Another study conducted within the South African context also revealed a poor follow-up return rate of 33% [28]. Default on follow-up return rates were attributed to the long waiting period before follow-up appointments, parents changing their mobile phone number and not notifying the ECD center, a lack of transportation, and difficulties with taking leave from work, which may result in loss of income for informal workers [29].

The use of smartphone hearing screening within ECD centers provided solutions to challenges often faced when testing in LMICs, such as the costs of equipment, lack of trained personnel and ambient noise in the test environment [29]. However, a limitation of using this method of screening, as opposed to objective hearing screening measures such as otoacoustic emission (OAE) testing or auditory evoked potentials (AEPs), is that children younger than four years of age could often not be conditioned to respond reliably at ECD centers or at their follow-up clinic [8, 29]. These children were referred to other healthcare facilities for such objective tests.

Of the 270 children who were seen for a follow-up assessment, 9.3% had failed the hearing screening due to the presence of impacted cerumen. Unfortunately, due to limited resources and time constraints at local clinics, these children were unable to receive a pure tone threshold test and were referred for treatment. Previous studies conducted within other low income communities in sub-Saharan Africa also revealed high incidence rates of impacted cerumen ranging between 6.6% and 38% [15,19,28].
High incidence rates of excessive and impacted cerumen indicate a need for appropriate services to ensure required intervention. Impacted cerumen can cause a mild hearing loss, which may interfere with a child’s academic performance and cause behavioral problems in the classroom [30]. Furthermore, a study by Olusanya [31] found that children with a history of impacted cerumen were more like to have otitis media with effusion or a hearing loss of a more permanent nature. Thus the prevention of childhood hearing loss caused by cerumen impaction should be a public health concern, especially where there is no routine and systematic screening for hearing disorders [31].

In comparison to previous studies, bilateral hearing loss (56.5%, 26/46) was found to be more common than unilateral hearing loss [15,32]. Appropriate management of both bilateral and unilateral hearing loss is important since even a unilateral hearing loss increases rates of grade failure, the need for additional educational assistance, and perceived behavioral issues in the classroom [2,33,34].

Gender and age did not have a significant effect on results, in accordance with those previously reported by Mahomed-Asmail et al. [15]. Conductive hearing loss (12.2%, 30/245) was the most common type of loss followed by sensorineural (5.3%, 13/245) and mixed (1.2%, 3/245) losses (Table 3). A study by Swart [35] on 2457 first year entry school children in the South African industrial areas of Witbank and KwaGuqa also found conductive hearing loss to be more common with bilateral sensorineural deafness present in 2.1 per 1000 and 6.5% of participants presenting with middle ear disease. Another more recent study conducted in Zimbabwe identified conductive and sensorineural hearing losses in 1.4% (79/135) and 1.0% (56/135) of preschool children tested respectively [18]. High incidence rates in the current study indicates a need for referral services in South Africa in order to ensure for appropriate treatment and follow-up service. Otitis media may account for the high incidence rate of conductive hearing loss, with acute otitis media and otitis media with effusion reported to be the most common cause of hearing loss in children between the ages of two to five years, particularly within LMICs [20,21,36].

5. Conclusion

A hearing loss was identified in 18.7% of pre-school children who attended their follow-up diagnostic assessments, thus ensuring the continuation of medical or audiological services where needed. Results indicated that most preschool children who failed their hearing screening and received a diagnostic assessment needed intervention services for conductive hearing loss (65.2%), followed by sensorineural (28.2%) and mixed losses (6.5%). Cerumen impaction was also a common finding amongst preschool children. While these results may assist in the effective implementation of hearing screenings for pre-school children, true hearing loss prevalence data for young children in LMICs like South Africa still remains elusive with majority of research focused on the school aged population. This makes the planning and provision of hearing health services within the preschool aged population challenging [37].

6. Acknowledgements

We would like to thank all the participants involved with this study, including the team leaders, community health workers and audiologists of the community of Mamelodi.

7. Conflict of interests

The second author is the co-founder and scientific advisor to the hearX group.

8. Funding

The financial assistance of the National Institute for the Humanities and Social Sciences, in collaboration with the South African Humanities Deans Association towards this research is hereby acknowledged. Opinions expressed and conclusions arrived at are those of the author and are not necessarily to be attributed to the NIHSS and SAHUDA.

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