Impact of preschool hearing screening in low-income communities: Program outcomes and caregiver perspectives

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Conflicts of interest

De Wet Swanepoel has a financial relationship with the hearX Group that includes equity, potential royalties and consultation. The other authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

ABSTRACT

Purpose: This study aimed to describe the impact of a preschool hearing screening program in a low- and middle-income country (LMIC) in terms of referral outcomes and caregiver perspectives.

Method: This study included two components. Firstly, a review of outcomes from a large-scale community-based hearing screening program, facilitated by community health workers (CHWs), for preschool children who failed their hearing screening. Secondly, telephonic surveys were conducted with i) 25 caregivers whose children attended follow-up appointments and were diagnosed with hearing loss and ii) 33 caregivers whose children did not attend follow-up appointments.

Results: Over 21 months, 13,322 children underwent hearing screening, with an initial referral rate of 6% (809). Follow-up tests at preschools covered 86.2% (697) of children who failed the initial hearing screening; of whom 47.8% (387) presented with hearing loss and were referred for further evaluation. Among the 190 attending follow-up appointments, 54.8% (104) were diagnosed with hearing loss. Of these, 71.1% (74) had conductive hearing loss, 12.5% (13) had sensorineural hearing loss, and 13.5% (14) had mixed hearing loss. Caregivers strongly supported (96%) community-based hearing screening for preschool aged children. Notably, attendance varied significantly between preschool re-screenings (86.2%) and healthcare facility follow-up appointments (49.1%). Caregivers highlighted barriers to attend hearing services including, work commitments, long waiting times at healthcare facilities, miscommunication about referrals and appointments, relocations, and COVID-19 appointment cancellations.

Conclusions: This study highlights the effectiveness of community-based hearing screenings in LMICs, led by CHWs. It emphasizes strong caregiver support and the

importance of culturally relevant communication. Challenges in follow-up attendance persist, emphasizing the need for improved accessibility and communication within healthcare systems. Prioritizing caregiver concerns and promoting culturally sensitive education are essential for improving outcomes.

Keywords: Preschool, decentralised, community-based, hearing screening, low-and-middle income countries, hearing loss, mobile health technology (mHealth), outcomes, telephone survey, caregivers, follow-up default

INTRODUCTION

Childhood hearing loss is the second most prevalent disability globally, affecting at least 34 million children under the age of 15 years, with sub-Saharan Africa (SSA) exhibiting one of the highest prevalent rates (Olusanya et al., 2020; World Health Organization [WHO], 2021a). Research indicates that the prevalence of hearing loss in SSA children aged between 5 and 9 years is 4.5%, exceeding the 2.2% in high-income countries (Olusanya et al., 2020). Unaddressed hearing loss has long-term negative effects on a child's speech and language development, educational progress, cognitive and socioemotional development, as well as socioeconomic participation (Mathers et al., 2001; Muse et al., 2013; Suen et al., 2019; WHO, 2021b). This includes children who develop minimal, mild, and unilateral hearing loss, who often experience challenges such as reduced quality of speech production, difficulty perceiving speech in noisy environments, reduced sound localization, increased rates of grade failure, and greater fatigue compared to their normal-hearing peers (Grandpierre et al., 2018; Moore et al., 2020; Tharpe, 2007). Despite over 60% of hearing of loss cases among children being preventable, the incidence continues to rise, particularly in low- and middle-income countries (LMICs), which account for nearly half (48.9%) of all cases

(Adedeji et al., 2015). In LMICs, hearing services are sparse and not consistently accessible in public health care settings. Health systems in LMICs, often besieged by life-threatening diseases, tend to overlook hearing loss due to its nonlife-threatening nature (Chadha et al., 2018; WHO, 2021a). Environmental risk factors (infectious diseases, seasonality, tobacco smoke exposure, socioeconomic status), poverty, and malnutrition contribute to higher rates of hearing loss in these settings, highlighting the need for comprehensive hearing loss prevention and timeous intervention (Biagio et al., 2014; Chadha et al., 2018; Global Burden of Disease [GBD], 2021; Joint Committee on Infant Hearing [JCIH], 2019; Monasta et al., 2012; Swanepoel et al., 2009; WHO, 2018).

Although newborn hearing screening (NHS) has clear benefits in improving outcomes for infants with congenital and early onset sensory hearing losses, its potential remains unrealized in LMICs due to severely limited access to services (Olusanya et al., 2014; Scheepers et al., 2014; WHO, 2021b). Limiting factors to accessibility are multifaceted and include a lack of awareness and knowledge about hearing loss, societal stigma, an absence of systematic hearing screening programs throughout the life course, prohibitive equipment costs, a shortage of trained personnel, hearing health care professionals, and competing health care priorities (M. S. Harris & Dodson, 2017; Kamenov et al., 2021; Mulwafu et al., 2017; Olusanya et al., 2014; Scheepers et al., 2014; Swanepoel, 2023; Swanepoel, Clark, et al., 2010). Due to resource constraints, targeted screening where babies with risk factors for hearing loss are screened is the recommended approach to NHS in some LMICs (Health Professions Council of South Africa, 2018). The absence of legislation for NHS in LMICs in addition to the lack of awareness of its importance, typically result in

significant delays in diagnosis of hearing loss, with age of first diagnosis often being beyond 5 years of age (Olusanya, 2015; Scheepers et al., 2014).

In contrast, for many children in LMICs, school-entry hearing screening presents a critical first opportunity for the detection of hearing loss. Such early childhood screenings are pivotal, allowing for interventions before the commencement of formal education and potentially mitigating the adverse effects on linguistic development and educational outcomes. By identifying children with a range of hearing losses—from congenital and early onset sensory losses to late-onset, progressive, or fluctuating types, including both permanent and transient conditions—these screenings address a crucial gap in health care provision for children in these regions (American Academy of Audiology, 2011; Hall, 2017; Mahomed-Asmail, Swanepoel, & Eikelboom, 2016; Olusanya et al., 2014; Swanepoel et al., 2013).

Given the importance of early detection through school-entry hearing screenings, the active participation of caregivers becomes paramount in navigating the journey from identification to intervention (Sevinc & Senkal, 2021). In LMICs, limited community awareness about ear and hearing health issues often results in delayed diagnosis and treatment, exacerbating the challenges of managing hearing loss (WHO, 2018; Sevinc & Senkal, 2021). Understanding caregivers' experiences is important for hearing health professionals to provide family-centered care (Muñoz et al., 2015). Similar to many other health conditions, attitudes and beliefs about hearing loss are directly linked to behaviour, including the acceptance of diagnosis and adherence to treatments like hearing aids. Factors influencing these behaviours include personal attitudes, beliefs, misconceptions, and knowledge about hearing loss (Olusanya, 2015; van Zyl et al., 2020). Important issues for raising community

awareness include hearing loss and its common causes, simple and effective prevention strategies, the consequences of no treatment and the benefits of timely intervention (Swanepoel & Almec, 2008; Olusanya, 2009; Scheepers et al., 2014; Bright et al., 2017a). Research supports that these community-based education programs can improve caregiver knowledge and attitudes, thereby increasing the uptake of hearing screening services and timely interventions (Mulwafu et al., 2017; Kamenov et al., 2021).

Although community-based education programs show promise in increasing engagement with hearing health services, significant barriers to accessibility remain. Geographical obstacles and inadequate health care services often limit access, particularly in low-resource settings, making travel for follow-up assessments and interventions burdensome (Ravi et al., 2016; Swanepoel, Clark, et al., 2010). Accessibility is not merely physical; it encompasses the affordability of indirect costs like transportation and time, often beyond reach for those in low-income groups (B. Harris et al., 2011; Swanepoel & Clark, 2019). Even when ear health services are nominally free, the associated indirect expenses can be prohibitive, resulting in missed follow-up appointments and a lack of understanding about the importance of continued care (Bright, Mulwafu, et al., 2017; Kanji & Khoza-Shangase, 2018; Scheepers et al., 2014). Overcoming these barriers is critical for the efficacy of screening programs and ensuring that early detection leads to timely and effective intervention (Bright, Mulwafu, et al., 2017; Kanji & Khoza-Shangase, 2018).

In response to the challenges of delivering hearing health care within LMICs, there has been a significant increase in research on community-based services (Dillard et al., 2024). These programs notably incorporate community health workers (CHWs) and leverage service-delivery models based on mobile health (mHealth)

technologies, including smartphone and internet platforms, to provide accessible hearing services (Eksteen et al., 2019; Frisby et al., 2022; Swanepoel, 2023). These models offer the potential to facilitate basic ear and hearing care services, which can be employed through task sharing by minimally trained persons, such as CHWs from the community, thus reducing the demand on already limited ear and hearing health professionals (Eksteen et al., 2019, 2021; Swanepoel, 2020, 2023). A decentralized, mHealth-supported approach to hearing screening services facilitated by CHWs has demonstrated the ability to provide low-cost, user-friendly, acceptable, and accessible services, contributing toward improved early identification of and treatment for disabling hearing loss in LMICs (Eksteen et al., 2019, 2021; Manus et al., 2020; Swanepoel, 2023; Yousuf Hussein et al., 2016).

Studies have demonstrated the feasibility and efficacy of community-based childhood hearing screening programs in LMICs yet there is a lack of data regarding their long-term impact, especially for children who do not pass the initial test and require further assessment. The prevalent issue of non-attendance at follow-up appointments is a significant barrier, highlighting the necessity for detailed research to understand the underlying causes and improve program effectiveness (WHO, 2021a; Clark & Swanepoel, 2014; Swanepoel, Clark et al., 2010; Yousuf Hussein et al., 2018; Swanepoel, Mngemane et al., 2010; Eksteen et al., 2019, Eksteen et al., 2021). Further exploration into caregivers' perspectives on these screening programs is crucial to reveal insights that can guide enhancements in healthcare delivery for children, as well as support program implementation, acceptance, and community impact (Russ et al., 2004).

The current study therefore investigated the impact of a community-based preschool hearing screening program facilitated by CHWs using mHealth technologies

in low-income African communities. The program's impact was evaluated based on outcomes for children who referred their community-based hearing screening as well as caregiver experiences and perspectives of the community hearing screening, referral process, treatment outcomes and reasons for follow-up default.

MATERIALS AND METHODS

This study received Institutional Review Board approval from the Faculty of Humanities Research Ethics Committee, University of Pretoria (HUM031/0622).

Study Design

This study included two components. Part one was a retrospective descriptive review of hearing screening outcomes from children who referred their community-based hearing screening and required further assessment and intervention. The second part of this study included two cross-sectional prospective telephonic caregiver surveys that were conducted to describe experiences and perspectives of the community hearing screening, referral processes, treatment outcomes and reasons for follow-up default.

Study population

The *3E: Ears and Eyes for Education* project screens the hearing and vision of children aged 4 to 7 years old at preschool centres in underserved communities in the Western Cape, South Africa; including Khayelitsha, Mitchells Plain and surrounding areas. In South Africa, preschool children are typically defined as those who are six years of age or younger and have not yet started formal schooling (Department of Basic Education, 2015). However, in the context of this research study, the term "preschool"

will be utilized for all children screened between the ages of 4 to 7 years old, as it aligns with the longitudinal nature of the study. The combined population of Khayelitsha and Mitchells Plain was estimated as 702,234 in 2011 (most recent available census data), including 61,094 children aged 5-9 years (StatsSA, 2011). The majority of the population are not native English speakers (StatsSA, 2011). The majority (97.0%; 181,145/186,803) of households within the study area are categorized as low- and middle-income, with 15.7% (29,408/186,803) having no income (StatsSA, 2011; Eksteen et al., 2019).

Children who underwent a community-based second hearing screening between 01 July 2018 and 31 March 2020, and who were referred for further follow-up assessment and intervention at hearing healthcare facilities, were considered eligible participants for this study. Two different caregiver subgroups, a) caregivers with children who attended following-up appointments and were diagnosed with hearing loss and b) caregivers of children who did not attend follow-up appointments were contacted regarding their willingness and availability to participate in a telephonic survey. Cross-sectional prospective telephonic surveys were conducted between October and November 2022.

Hearing screening program

The *3E: Ears and Eyes for Education* project, initiated in September 2017, appointed and trained six CHWs to conduct hearing and vision screening of preschool children using mHealth software applications on smartphones. Being members of the community themselves, these CHWs understood the community's context, language, cultural beliefs as well as biases regarding health services. None of the CHWs had any prior formal training in hearing or vision healthcare. The project audiologist

conducted a 5-day training course for the CHWs, covering hearing and vision theory, the screening process, hands-on training with the equipment, and assessment of children's responses. The project audiologist also supervised screening in the field for 2 days. Thereafter, weekly team meetings were held to provide opportunities for retraining as required (Eksteen et al., 2019; Eksteen et al., 2021). Participating preschools were mapped, and their principals agreed to the screening. Caregivers consented for their children's screening and granted permission for research. To increase accessibility, the caregivers were provided with the option to complete the form either in English or in their native language. The hearing screening used a digital audiometer application (hearScreen™, hearXgroup, South Africa) HD280 Pro headphones (Sennheiser, Wedemark, Germany) that on a Samsung A3 Android smartphone (Android OS, v8.0) and connected to supra-aural Sennheiser had been calibrated (International Organization for Standardization, ISO 389-1). The mobile application includes real-time environmental noise monitoring for quality control purposes (Swanepoel et al., 2014; Yousuf Hussein et al., 2018). If a screening test was failed, an immediate rescreen was done for the frequencies failed (Figure 1). Once the test was complete, the app presented an automated pass or fail result which was calculated using a predetermined protocol. Thresholds for failing the initial screening were set at 25 dB hearing level at 1, 2 and 4 kHz from July until December 2018, and 30 dB HL at 1 kHz and 25 dB HL at 2 and 4 kHz from January 2019 to March 2020. The fail criteria for the first protocol (from July until December 2018) constituted a no-response on one or more frequencies in either ear. The second protocol (from January 2019 until March 2020) required two or more no-responses in either ear (Eksteen et al., 2021).

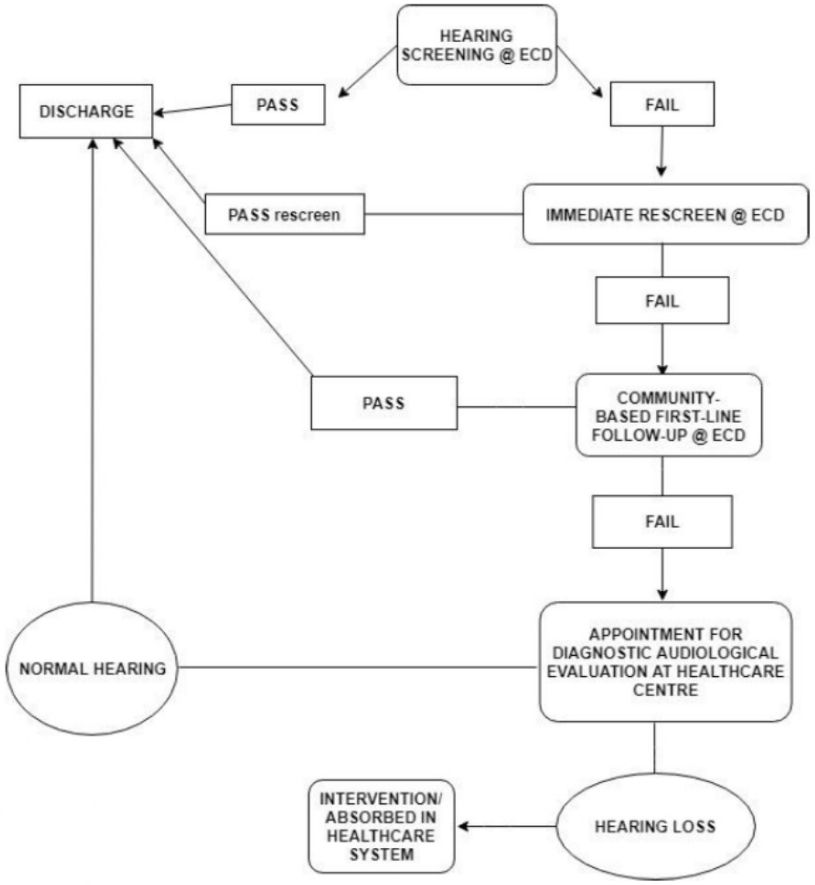

Figure 1

Figure 1. Community-based hearing screening service delivery model. ECD = early childhood development center.

Children who referred the initial hearing screening received a community-based second screen at their preschool by the project audiologist using the hearTest™ application (hearXgroup, South Africa), together with otoscopy (Welch Allyn pocket junior otoscope), within 1-2 weeks. Due to constraints in equipment, time, and human resources, the screening protocol did not include tympanometry or bone-conduction audiometry. According to the World Health Organization (WHO), tympanometry is

considered optional in screening protocols and may be limited in low-resource settings due to several factors, primarily cost constraints and resource availability. In such contexts, the cost of equipment, maintenance, and trained personnel can be prohibitive, making it challenging to include tympanometry as a routine part of hearing screenings. As a result, WHO emphasizes that tympanometry should only be conducted where feasible, while still aiming to deliver essential ear and hearing health services (WHO, 2021). Children with cerumen impaction received local primary healthcare clinic treatment, followed by a hearing re-screen. Those with suspected permanent hearing loss were referred to district hospital audiologists. Fail criteria constituting a referral to the local public healthcare facility for further assessment and intervention, was based on a four-frequency pure tone average (4FPTA) (500, 1000, 2000 and 4000 Hz) in the better hearing ear. Degree of hearing loss was largely based on the classification by the World Health Organization (<25dB HL “normal hearing”, 26–40 dB HL being “mild”, 41–60 dB HL “moderate”, 61–80 dB HL “severe” and 81 dB HL or greater “profound”) (WHO, 2023); 25 dB HL was included in the “mild” category. Caregivers were informed about this follow-up appointment through a written letter and were subsequently reminded via telephone (either through text message or phone call), as well as through communication with the teachers, prior to the appointment day. Audiology and hearing-related services are free at this point of care in these low-income communities.

Data Collection Materials and Procedures

Part 1: Retrospective Record Review

Retrospective data of a preschool hearing screening program that was collected between 01 July 2018 and 31 March 2020 (21-month period) was utilized to identify

participants who referred the community-based second hearing screening and were referred for further assessment and intervention at hearing healthcare facilities (Eksteen et al. 2019). Data and results from the 3E screening program conducted at preschools were synchronised to the secure cloud-based data management system (mHealth studio™, hearX Group, South Africa) through connected cellular networks at the end of each test (Mahomed-Asmail et al., 2016a; Swanepoel et al., 2014).

De-identified data was exported from a secure cloud-based data management system (mHealth studio™, hearX Group, South Africa) onto an Excel spreadsheet, using Microsoft Excel 2018 (Microsoft Corp. Redmond, WA, USA) for descriptive statistical analysis. The de-identified data spreadsheet included demographic information, contact details of the caregivers and community-based second screening results. Some additional data was obtained from field notes recorded by the involved CHWs and the project audiologist which included information on referrals made, feedback from referral pathways, attendance rate, test results and outcomes of follow-up appointments. Field notes were also used as a cross check for the retrospective review of the hearing screening program data. The finalized Microsoft Excel data spreadsheet included de-identified information on referrals and appointments, attendance of appointments, test results and intervention.

Part 2: Prospective Telephonic Caregiver Survey

To ensure the telephonic surveys accurately measured what it was intended to (Leedy & Ormrod, 2020), a review of published articles and consultation of questionnaires and protocols from prior studies in the field were conducted to achieve content validity (Bright et al., 2017a; Eksteen et al., 2019; WHO, 2021a; Sevinc & Senkal, 2021; Russ et al., 2004). These surveys focused on caregivers' views on and experiences of

community hearing screening, referral processes, treatment outcomes and reasons for follow-up default. The surveys were conducted in English, with question simplicity ensured using *Readable.com.com*, a tool that assesses text readability across various indices (Readable, 2023). Both surveys achieved a 100% reach score, indicating full comprehensibility for the target audience, roughly equivalent to 85% of the literate general public. Additionally, both surveys scored an average grade level of 8, suitable for the general public's understanding. This level aligns with the literacy rate in South Africa, where functional illiteracy is defined as not completing Grade 7. Most recent data from 2019 indicates a 7.4% illiteracy rate of people ages 20 and above in the Western Cape (Khuluvhe, 2021).

Survey 1: Caregiver perspectives of community hearing screening, referral process, and treatment outcomes

The survey consisted of three sections, and a total of 19 items were included: 13 close-ended questions and 6 open-ended questions. A three-point Likert-type rating scale (1 indicating yes; 2 indicating unsure; 3 indicating no) was used for certain close-ended questions of the survey (Supplemental material A).

Survey 2: Caregiver reasons for follow-up default

The survey consisted of three sections and a total of 16 items were included: 10 close-ended questions and 6 open-ended questions. A three-point Likert-type rating scale (1 indicating yes; 2 indicating unsure; 3 indicating no) was used for certain close-ended questions of the survey (Supplemental material B).

The sections with open-ended questions were included to attain a better understanding of the perceived impact of community-based screening programs in

LMICs, from hearing loss detection through to treatment and reasons for follow-up default. Caregivers were contacted telephonically and the verbal consent was read to them to validate their participation in the study. On confirmation of consent, the survey was carried out by the researcher, which took between 10 and 15 minutes to complete. All survey information was captured manually in hard copy by the researcher, and was later recorded electronically for analysis.

Telephonic caregiver surveys pilot study

The two newly developed surveys underwent a pilot study to identify and adjust any biased or unclear questions, thereby ensuring coherence, relevance, and the elimination of potential bias before data collection began. Feedback from two caregivers of children who referred the community-based second hearing screening and two experienced audiologists helped simplify and adjust survey questions. Based on the feedback received, the surveys were reviewed and adapted to improve their content, question clarity and relevance, structure, order, and overall length.

Data Analysis

Raw data were captured in Microsoft Excel 2018 (Microsoft Corp. Redmond, WA, USA) to ensure accuracy, consistency, and reliability, minimizing the risk of data collection errors. Quantitative data analyses consisted of descriptive statistics, focusing on central tendency, measures of variability and internal consistency of two Likert-scale survey sections. Survey data collection only took place once verbal consent was obtained and recorded by the researcher. A thematic analysis was conducted for answers to open-ended questions from the telephonic surveys following Braun and Clarke's (2006) guidelines. This process was carried out by two

researchers using an inductive approach due to limited literature on decentralised community-based preschool hearing screening in LMICs. The primary researcher conducted the telephonic surveys, manually recorded the participants' responses, and subsequently transcribed the interviews verbatim to ensure accuracy and precision throughout the telephonic surveys. Transcripts were then checked against the recordings for accuracy by the primary researcher. Following the proofing process, transcripts were then de-identified by the primary researcher. This was achieved by assigning an alphanumeric code to each caregiver participant which corresponded to the relevant part one participant to merge the survey data with the retrospectively obtained data. The primary researcher then read each transcript multiple times to become familiar with the data. Initial thoughts about the research questions were recorded and referred to when creating codes. The co-researcher then assisted the primary researcher with grouping transcript sections into meaningful categories related to the research topic. These categories were then examined by the primary researcher and cross-examined by the co-researcher for patterns, leading to the identification of themes. These themes included caregivers' perspectives of community hearing screening, referral process, treatment outcomes and reasons for follow-up default, with categories and subcategories. Coded data excerpts were examined by both researchers, and all transcripts were re-read by the primary researcher to ensure that the identified themes accurately represented the content of the surveys. The analysis was an ongoing and iterative process, until categories aligned well with the data. Survey data were managed electronically by the researcher on a Microsoft Excel spreadsheet by the researcher with an alphanumeric code to maintain confidentiality.

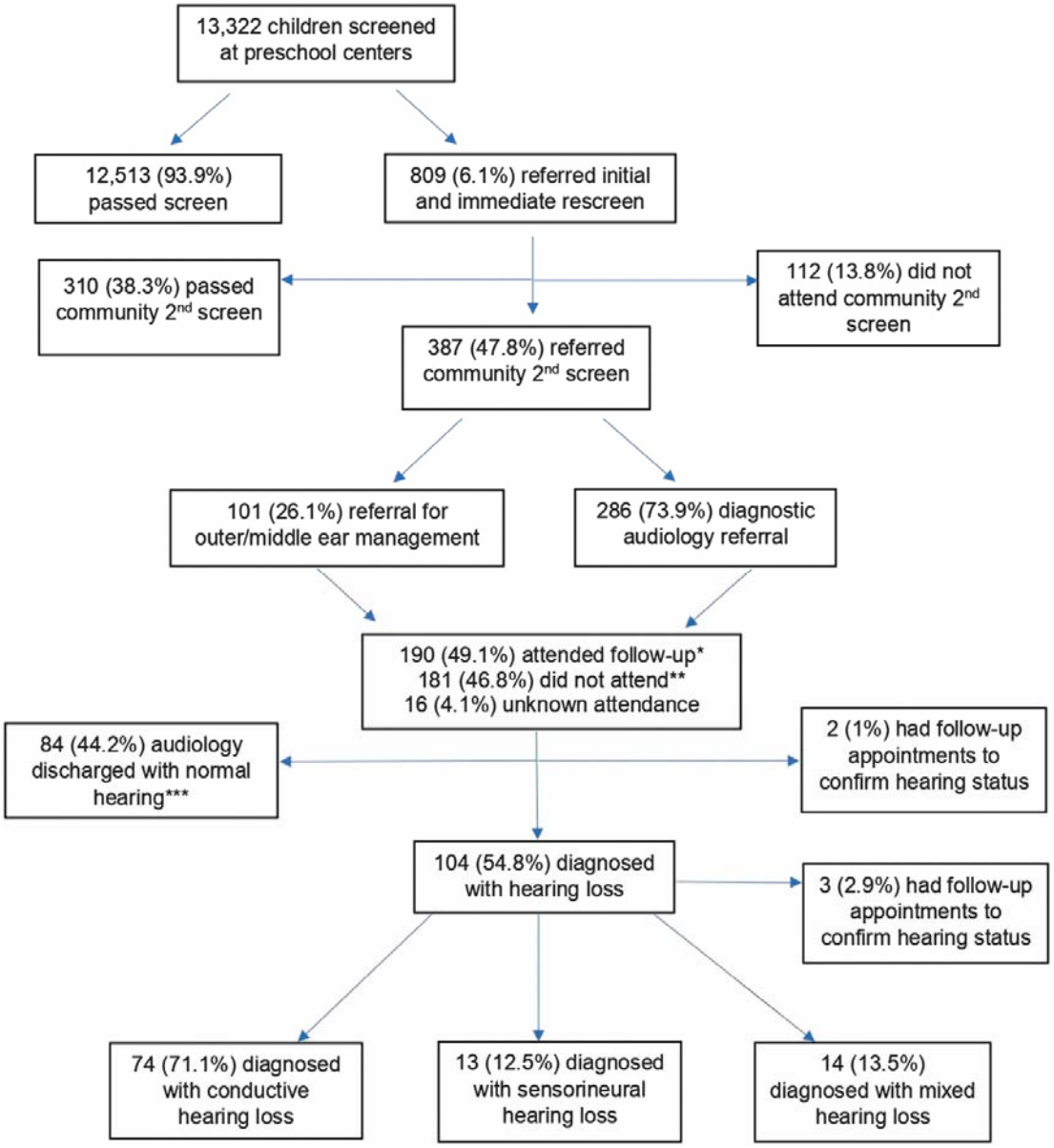

Figure 2. Flowchart of community-based preschool hearing screening program outcomes. *These children attended either the district local audiology follow-up appointment (152 of 190) or the local primary health care clinic (38 of 190). **These children did not attend either the district local audiology follow-up appointment (121 of 181) or the local primary health care clinic (60 of 181). ***These children were found to have hearing within normal limits bilaterally (4FPTA of < 25 dB HL; WHO, 2023) and were discharged from further audiological services. Those children who needed other developmental interventions were referred accordingly.

RESULTS

Part 1: Community Hearing Screening Project Outcomes

During 01 July 2018 to 31 March 2020 (21-month period) a total of 13,322 children aged between 4.0 and 7.1 years old, had their hearing screened (Figure 2). Of these children, a total of 809 referred the initial and immediate rescreen and were referred for a community-based second hearing screening (Figure 2). Of these 809 children, 14% (112/809) were absent on the day of the second screening, 38% (310/809) passed and were discharged from the program and 48% (387/809) presented with hearing loss and were referred for further assessment and intervention services (Figure 2). All 387 children who were referred for follow-up were included in this study with a mean age of 5.8 years of age (0.60 SD; range 4.12 - 7.09 years) (Table 1) of which 54% (208) were female and 46% (179) were male (Table 1).

Table 1

		% (n) **Distribution of participants**
Gender	Female	54% (208)
	Male	46% (179)
Age	4.0 – 5.0 years	12% (45)
	5.1 – 6.0 years	51% (197)
	6.1 - 7.1 years	37% (145)

*Notes: *Due to rounding, percentages may not precisely reflect the absolute figures*

Follow-up Assessment and Intervention

Of those children who referred the community-based second screening, 74% (286/387) had no obvious signs of external and/or middle ear abnormalities and were referred directly to the local audiologist for further diagnostic evaluation. Furthermore, almost a third (26%; 101/387) of the children were observed to have abnormal outer

and middle ear abnormalities such as cerumen impaction, otitis media, tympanic membrane perforations, and foreign objects at the community-based second screening and were referred to their local primary healthcare clinic for further investigation and possible management (Figure 2). Of those children who attended their follow-up appointment, 44% (84/190) presented with normal hearing and were discharged from primary healthcare services. In instances where information pertaining to follow-up attendance was unknown (4.1%; 16/387), and where children had additional follow-up appointments to confirm their hearing status (1%; 2/190), these children stayed within the public healthcare system but no longer formed part of the group of children identified as having hearing loss following diagnostic audiological evaluation (Figure 2).

Prevalence of Hearing Loss

Prevalence of hearing loss at the time of the follow-up appointment ranged between 0.79% (104/13,322) when assuming none of the non-attending and unconfirmed children had hearing loss and 2.3% (303/13,322) assuming all non-attending and unconfirmed children presented with hearing loss. Of the children in the total sample who passed the community-based second screening, attended their follow-up, and were diagnosed with hearing loss, 71% (74/104) were diagnosed with conductive hearing loss, of whom 72% (53/74) were bilateral cases and 28% (21/74) were unilateral (Table 2). Furthermore, 13% (13/104) of the children were diagnosed with sensorineural hearing loss, of whom 54% (7/13) were bilateral cases and 46% (6/13) were unilateral (Table 2). An additional 13% (14/104) were diagnosed with mixed hearing loss, of whom 50% (7/14) were bilateral cases and 50% (7/14) were unilateral (Table 2).

Table 2 Characteristics of children diagnosed with hearing loss (*n* = 104).

Characteristics	% (n) Bilateral HL	Unilateral HL	Total HL
Conductive HL	**72% (53/74)**	**28% (21/74)**	**71% (74/104)**
Medical treatment received	71% (52/74)	28% (21/74)	99% (73/74)
Bone conduction hearing aid (unilateral)	1% (1/74)	0% (0)	1% (1/74)
Sensorineural HL	**54% (7/13)**	**46% (6/13)**	**13% (13/104)**
Bilateral BTE hearing aids	15% (2/13)	0% (0)	15% (2/13)
Unilateral BTE hearing aid	8% (1/13)	15% (2/13)	23% (3/13)
Bimodal (cochlear implant, BTE hearing aid)	8% (1/13)	0% (0)	8% (1/13)
Caregiver refusal for treatment/intervention	15% (2/13)	0% (0)	15% (2/13)
Follow-up appointment	8% (1/13)	31% (4/13)	39% (5/13)
Mixed HL	**50% (7/14)**	**50% (7/14)**	**13% (14/104)**
Medical treatment received	50% (7/14)	29% (4/14)	79% (11/14)
Unilateral BTE hearing aid	0% (0)	14% (2/14)	14% (2/14)
Unilateral assistive listening device	0% (0)	7% (1/14)	7% (1/14)

Notes: Boldfaced values indicate the total number of children diagnosed with bilateral conductive hearing loss. BTE = behind the ear.

**Due to rounding, percentages may not precisely reflect the absolute figures*

Interventions and Treatment

Of the children diagnosed with sensorineural hearing loss, 46% (6/13) were provided with behind-the-ear (BTE) hearing aids and/or cochlear implant, 15% (2/13) had caregivers who refused treatment or intervention, and 39% (5/13) required follow-up appointments for confirmation of their hearing status (Table 2). Among children diagnosed with conductive hearing loss, the primary contributors included conditions affecting the outer and middle ear, such as cerumen impaction, otitis media, tympanic membrane perforations, and the presence of foreign objects. The majority of these children, d99% (73/74) underwent successful medical treatment, and 1% (1/74) were fitted with a unilateral bone conduction hearing device (Table 2). Among those children diagnosed with mixed hearing loss, 79% (11/14) underwent successful medical treatment, 14% (2/14) were fitted with a unilateral BTE hearing aid, and 7% (1/14) received a unilateral assistive listening device (Table 2). Although 99% and 79% of

children with conductive and mixed hearing loss respectively, were successfully treated medically, it is not possible to determine exactly how many children's hearing loss fully resolved after treatment. This is because no follow-up audiological information beyond the initial diagnosis was made available at the time of the study. Without post-treatment hearing assessments, we cannot confirm whether the medical intervention completely restored their hearing or if any residual hearing loss remained. An additional 3% (3/104) had follow-up appointments to confirm their hearing status (Figure 2). No additional radiological, medical and audiological investigations into the etiological factors were conducted at the time of the study.

Part 2: Prospective Telephonic Caregiver Surveys

Survey 1: Caregiver perspectives of screening, referral process, and treatment outcomes

In the survey involving caregivers of children who had attended follow-up appointments, out of the 48 caregivers contacted, 25 (52%) completed the survey, with 21 unreachable and 2 declining participation. Most caregivers (68%; 17/25) reported their child's hearing was screened for the first time by the 3E hearing screening program (Table 3), and most (92%; 23/25) received and understood the screening process in their preferred language, enhancing accessibility and comprehension (Eksteen et al., 2019). Prior to hearing screening, 68% (17/25) of caregivers had concerns about their child's hearing, speech and language development, while 28% (7/25) did not have concerns (Table 3). Post-screening, 92% (23/25) of caregivers reported understanding the screening results. The majority (96%; 24/25) of caregivers believed the hearing screening program benefitted their child, with 92% (23/25) finding the follow-up appointments at the clinic/hospital beneficial. Almost

a third (32%; 8/25) of participants' children were fitted with hearing devices of which 75% (6/8) remained active users (Table 3). Those caregivers (25%; 2/8) who indicated their child is not a consistent hearing aid user, attributed it to lack of batteries for the hearing aids, continuous acoustic feedback from the hearing aids, and misplaced hearing aid parts.

Table 3. Caregivers of children who attended the follow-up appointment: Investigating perspectives of community hearing screening, referral process, and treatment outcomes (*n* = 25).

	n (%)		
Survey item	**Yes**	**Unsure**	**No**
Was your child's hearing screened at birth?	10 (40%)	7 (28%)	8 (32%)
Was your child's hearing screened for the first time by the 3E hearing screening programme?	17 (68%)	0 (0%)	8 (32%)
Did you receive information explaining the hearing screening process at the school?	23 (92%)	0 (0%)	2 (8%)
Are you aware of the hearing screening results?	19 (76%)	1 (4%)	5 (20%)
Were you concerned about your child's hearing or speech and language development?	17 (68%)	1 (4%)	7 (28%)
It was recommended that you bring your child for a follow-up appointment. Did you understand what you were supposed to do?	23 (92%)	1 (4%)	1 (4%)
Were you present during your child's follow-up appointment?	23 (92%)	0 (0%)	2 (8%)
Were the hearing test results explained to you?	22 (88%)	1 (4%)	2 (8%)
Did you understand the hearing test results?	23 (92%)	1 (4%)	1 (4%)
Did the 3E screening programme help your child?	24 (96%)	1 (4%)	0 (0%)
Did the visit to the hospital/clinic help your child?	23 (92%)	0 (0%)	2 (8%)
Was your child fitted with hearing aids?	8 (32%)	0 (0%)	17 (68%)
Does your child wear his/her hearing aids? (N = 8)	6 (75%)	0 (0%)	2 (25%)
If YES (in the above question), is your child benefitting from his/her hearing aids? (N = 6)	6 (100%)	0 (0%)	0 (0%)

*Notes: *Due to rounding, percentages may not precisely reflect the absolute figures*

Through thematic analysis of open-ended survey responses from 25 caregivers, five key themes emerged which highlighted their perspectives of community hearing screening, treatment outcomes (treatment by means of hearing aids or medical treatment) and recommendations for future hearing screening programs (Tables 4 and 5). Caregivers voiced a generally positive stance toward the community hearing screening, citing increased awareness of the importance of healthy hearing for learning. They found the hearing screening program to be educational and helpful, and indicated that the program proactively addressed pre-existing concerns about their child. Notably, caregivers reported observing marked improvements in their children's hearing, communication, and behaviour, as well as academic and social enhancements post-treatment.

Survey 2: Caregiver reasons for follow-up default

In the survey involving caregivers whose children did not attend follow-up appointments and were invited to participate in the telephone survey, out of the 75 caregivers contacted, only 44% (33/75) participated (40 caregivers could not be reached and 2 declined). Most caregivers (64%; 21/33) knew about their follow-up appointments, but did not attend (Table 6). Regarding appointment notifications, most caregivers (70%; 14/20) reported receiving written feedback (letter), 30% (6/20) a phone call, 5% (1/20) received a text message and 10% (2/20) were informed by a teacher. However, more than a third (36%; 12/33) reported not receiving any notification about their follow-up appointment (Table 6).

Table 4. Thematic analysis of caregiver perspectives and experiences of community hearing screening (*n* = 25).

Themes	Sub-themes	Examples/ illustrative quotes
Screening experience	Positive experience	*"Experience was good overall"* *"It was a positive experience for us"*
	Increased awareness for importance of hearing	*"It opened my eyes. I never thought to check his ears before"* *"People are not aware of hearing loss- and we just think the child is being naughty"*
	Learning experience	*"I learned a lot about hearing and ears from the experience"* *"They (the audiologist) explained the information more to me and I understood that he needed a hearing aid"*
	Helpful	*"The letter and information we received from 3E from the school helped us to get help faster in our community"* *"If it wasn't for the letter of 3E I wouldn't have got help so quickly"*
	Addressed existing concerns	*"The teacher was also very concerned like I was"* *"I was very concerned about my child. There were behavioural issues and she wouldn't take part in activities at school. I didn't know it was a hearing problem"*
Caregivers' recommendations for future screening programs	Raise community awareness on hearing loss	*"People need more information about hearing loss and how to look after ears and prevent hearing loss"* *"I think there should be more information about hearing and ears everywhere not just at schools- but in malls, community centres"*
	Decentralised hearing screening services at community level	*"Every child should be tested at a young age at the clinic. Hearing screening must be available at every baby clinic so that the child can be helped"* *"If we can have a hearing screening system at schools across all communities"*

At the time of the survey, most caregivers had no concerns regarding their child's hearing (73%; 24/33) or speech and language development (79%, 26/33) (Table 6). Despite missing the follow-up appointment, most caregivers (67%; 22/33) recognized the potential negative impacts of hearing loss on their child's development (Table 6). The majority of caregivers (69%, 22/32) showed interest in rescheduling a follow-up test for their child.

Table 5. Thematic analysis of caregiver perspectives and experiences of treatment outcomes of their children (*n* = 25)

Themes	Subthemes	Examples/ illustrative quotes
Treatment experiences	Positive	*"It (the HA) is helping a lot. You can see the importance of the hearing aid"* *"Now I feel good. We can see that it has changed all our lives for the better. I enjoy every moment with my child now"*
	Increased caregiver awareness	*"Now we know he can hear. His new school (Carel du Toit) (the teachers, therapists) have taught us a lot"* *"I was helpless. I never knew anything about the hearing problem before now"*
Changes – since treatment received	Improved hearing	*"Previously my child would rely on his peers when playing games and doing schoolwork because he did not understand the instruction or understand us and now he hears and understands us better"* *"I do not have to repeat myself as often as I used to"*
	Improved ear health	*"The leaking ear is under control"* *"Since they treated my child's ear infection, my child did not complain of ear pain after that"*
	Improved academic performance	*"Improved marks at school"* *"His schoolwork (academics) became better after he got grommets"*
Changes – since hearing aid fitting	Improved hearing	*"He can hear very well now. He listens well and now with the HA on, he listens to the TV at a normal level"* *"Before the HA, I had to shout for his attention, but now he listens (hears) more and I only have to call once. I don't have to repeat as much as I used too"*
	Improved speech/language	*"He is more vocal than before"* *"She can now speak (a lot). Before my child's speech was very limited and now she can speak in full sentences"*
	Improved social skills	*"Now after the hearing aid, he is playing with children his own age"* *"He is taking part in activities in school"*
	Improved behaviour	*"His behaviour is better"* *"We used to struggle a lot with his behaviour but it's better now"*
	Improved academic performance	*"He is doing well at school now. His marks are better"* *"His education (academics) has got better"*

Table 6. Caregivers of children who did not attend the follow-up appointment: Investigating reasons for follow-up default (*n* = 33).

Survey item	n (%)		
	Yes	Unsure	No
Was your child's hearing screened at or shortly after birth?	15 (46%)	11 (33%)	7 (21%)
Did you receive information explaining the hearing screening process at the school?	30 (91%)	1 (3%)	2 (6%)
Are you aware of the hearing screening results?	23 (70%)	2 (6%)	8 (24%)
Do you have any concerns about your child's hearing?	8 (24%)	1 (3%)	24 (73%)
Do you have any concerns about your child's speech and language development?	7 (21%)	0 (0%)	26 (79%)
Are you aware of the negative impact hearing loss can have on a child's development?	22 (67%)	3 (9%)	8 (24%)
Are you aware your child had an appointment booked at the clinic/hospital?	21 (64%)	0 (0%)	12 (36%)

*Notes: *Due to rounding, percentages may not precisely reflect the absolute figures*

Thematic analysis of the open-ended questions from 33 caregivers revealed three themes related to reasons for not wanting another appointment, non-attendance and recommendations for future hearing screening programs (Table 7). The most common reasons for non-attendance were due to barriers and logistic constraints such as work commitments, long waiting times at healthcare facilities, miscommunication about referrals and appointments, relocations, and COVID-19 appointment cancellations. Caregivers also provided recommendations to support the need for the expansion of decentralized hearing screening services at schools, community centers, and mobile clinics. Raising community awareness about hearing loss, preventative measures, and signs to look for in children with hearing loss also emerged as a recurrent suggestion. Clear communication with caregivers about results of the hearing screening and follow-up appointment information as well as consideration of their work commitments were among the further recommendations provided.

Table 7. Thematic analysis of caregivers' reasons for follow-up default (*n* = 33).

Themes	Subthemes	Examples/ illustrative quotes
Not wanting another follow-up appointment	Disbelief (no concerns about child's hearing)	*"Not necessary- my child can hear….the tests that were used on the day of the hearing screening at school were not accurate"* *"There's nothing wrong with my child, I have no concerns"*
	Relocated	*"My child is in Eastern Cape now"* *"We no longer live in Cape Town. We moved after COVID"*
Follow-up default despite receiving date and time of the follow-up appointment	Appointment cancelled (COVID-19 global pandemic)	*"Due to COVID, our appointment got cancelled"* *"COVID. Appointments got cancelled and scared to go to the hospital during that time"*
	Relocated	*"My child relocated to Eastern Cape"* *"We moved to Joburg"*
	Disbelief (no concerns about child's hearing)	*"I know that he can hear. He does respond to sounds. He was already tested at birth"*
	Work commitments	*"It is difficult to take time off from work"* *"I didn't have time to take my child to the appointment because I am working nor did I phone for another appointment"*
Caregivers' recommendations for future screening programs	Raise community awareness on hearing loss	*"Some people don't know about it. Mom's for the first time need to learn about the importance of ears/hearing and the effects on learning"* *"No one tells you about hearing loss in our community. We need more information as parents and a community on ways to prevent hearing loss in children"*
	Decentralised hearing screening services at community level	*"Mobile clinics at community centres instead of going to local clinic and hospital"* *"Come into our communities and schools to do the screening"*
		"We should explain in layman's terms about the process of the screening" *"Communication and feedback should be done in a reasonable timeframe"*
	Consider caregiver work commitments	*"Can't take a full day off from work to attend a 1-hour appointment"* *"People don't have time to commit and attend all appointments. Accumulated leave becomes unpaid leave"*

DISCUSSION

This study aimed to describe the impact of a community-based preschool hearing screening program, facilitated by CHWs using mHealth technologies, in low-income African communities. Study findings emphasize the program's pivotal role in early

detection and management of hearing loss among preschool children, significantly enhancing their developmental prospects and wellbeing. Findings complement previous related studies (Eksteen et al., 2019; Eksteen et al., 2021; Yousuf Hussein et al., 2016, Manus et al., 2020). They provide insights into caregivers' perspectives of the program's impact on their children, their challenges in navigating follow-up processes, and the practical efficiencies and barriers encountered in implementing successful community-based hearing screening.

Hearing screening referral outcomes

The initial hearing screening referral rate of 6.1%, aligns with previous findings similar from low-income African communities, which report referral rates between 1.6% and 5.6% (Manus et al., 2020; Eksteen et al., 2019). A notable follow-up attendance of 86% among referred children (697/809) attended a second hearing screening, far surpassing the follow-up rates of 32.5% to 45.3% reported in similar LMIC healthcare contexts (Manus et al., 2020; Hussein et al., 2018). This suggests that community-based screenings conducted at preschools may significantly reduce barriers previously identified, such as financial constraints, travel distances, and time off work, thus facilitating access to specialized care and lessening the burden on public healthcare (Scheepers et al., 2014; Ravi et al., 2016; Bright et al., 2017a; Kanji & Khoza-Shangase, 2018; Eksteen et al., 2019; Jayawardena et al., 2020).

The findings from the second community-based screening highlight a significant prevalence of outer and middle ear pathologies among children, emphasizing the often-overlooked nature of these conditions. Many of these pathologies can lead to conductive hearing loss, which frequently remains undiagnosed until educational or behavioural issues become apparent around ages 4

to 5 years (Olusanya, 2015). This underscores the necessity of incorporating comprehensive screening tools like tympanometry to capture a broader spectrum of potential pathologies (Fitzpatrick et al., 2010; Fitzpatrick et al., 2014; Durieux-Smith et al., 2008). The findings highlight a significant prevalence of conductive hearing loss among children who were referred for further audiological assessment, with outer and middle ear conditions being the primary contributors. The predominance of bilateral cases aligns with existing literature (Yousuf Hussein et al., 2018; Kuschke et al., 2020). The high success rate of medical treatment for conductive hearing loss in this study highlights the critical role that timely medical interventions play in managing ear-related health conditions in children. This finding underscores the importance of prioritising medical approaches in the treatment of conductive hearing loss, particularly in cases associated with outer and middle ear pathologies. This study's finding aligns with global patterns that cite middle ear disease as a leading cause of paediatric hearing loss (WHO, 2021a). This highlights the need for robust referral services in LMICs for appropriate management and treatment. Early detection and treatment are vital to prevent learning difficulties, emphasizing the importance of addressing ear diseases promptly to safeguard hearing, speech, and language development in children (Shrivastava et al., 2016; Parmar, 2019).

The presence of permanent hearing losses, including sensorineural and mixed types, aligns with estimates from other hearing screening studies in LMICs, constituting estimates of permanent hearing losses in 27.9% of cases (Kuschke et al., 2020) and 34.7% of cases (Yousuf Hussein et al., 2018). The provision of hearing devices to children with sensorineural hearing loss highlights a significant role for amplification through hearing devices to manage more permanent hearing losses. Meanwhile, caregiver refusal of treatment in some sensorineural loss cases points to

lingering obstacles, such as stigma against childhood hearing loss or a lack of awareness about the implications of untreated hearing loss (Yousuf Hussein et al., 2018; Kuschke et al., 2020). In managing mixed hearing loss cases, the predominant reliance on medical treatment reflects a similar trend observed in conductive hearing loss cases, highlighting the importance of addressing ear-related health conditions in children. The provision of BTE hearing aids and assistive listening devices to a portion of these cases indicates a recognition of the need for amplification in specific circumstances, enhancing auditory access for those who may benefit from additional support.Overall, these results suggest a multifaceted approach to managing pediatric hearing loss, with a preference for medical intervention, particularly for conductive and mixed hearing loss. However, there is also recognition of the importance of hearing devices, especially for sensorineural hearing losses.

True prevalence of confirmed hearing loss at follow-up healthcare appointments could not be ascertained apart from an estimated range between 0.8% and 2.3%. This study's rates are conservative compared to the WHO's 1.9% prevalence figure for sub-Saharan African children aged 5 to 14 years, while Olusanya et al. (2020) report higher rates of 3.8% globally and 4.5% in sub-Saharan Africa for children aged 5-9 years, thus suggesting potential underreporting of hearing loss in this study. Factors such as non-attendance of preschool by children with known hearing loss or those awaiting diagnostic confirmation, along with those already enrolled in specialized programs, could contribute to this underestimation (Eksteen et al., 2019). Increased targeted screening in Cape Town has identified children with hearing loss before age 4 (de Kock et al., 2016; Kuschke et al., 2020). Improving follow-up attendance might reveal higher prevalence rates thus, fostering enhanced

collaboration among healthcare providers and screening programs is crucial to address these potential discrepancies and ensure accurate prevalence assessments.

Caregiver perspectives and experiences of screening and treatment outcomes

The high levels of understanding and acceptance among caregivers regarding the preschool hearing screening offered by the 3E hearing screening program are encouraging, indicating strong community support for decentralised community-based hearing screening programs in LMICs. Additionally, the significant comprehension of the referral processes and hearing test results reflects the program's effectiveness in communicating important information. The ability to receive information in their native language was a key factor in facilitating informed decisions and reducing miscommunication risks, underscoring the importance of culturally sensitive health communication strategies (Bright et al., 2017a; Ratna 2019; Sevinc & Senkal, 2021).These results support findings from other studies that have documented the positive attitudes of parents towards childhood hearing loss and healthcare services, demonstrating that caregiver engagement is a cornerstone of successful ear and hearing health services (Alsudays et al., 2020; Kaspar et al., 2021). Results from a recent South African study (van Zyl et al., 2020) investigating experiences of caregivers of children diagnosed with conductive hearing loss, also align with the perceived benefits reported by caregivers in this study, including improved hearing, communication, behaviour, academic performance, and ear health.

The recognition by caregivers of the critical link between healthy ears and hearing for optimal learning and development in their children, reflects a growing awareness of the importance of hearing health and education in LMICs. Furthermore, caregivers advocated for the expansion of decentralized hearing screening services,

encompassing schools, community centers, and mobile clinics to enhance accessibility. By decentralizing screening services, barriers such as transportation and scheduling conflicts can be minimized, potentially leading to earlier detection and intervention for children with hearing loss. Recommendations from caregivers to raise community awareness about hearing loss reflect a need for public education on the signs of hearing loss and preventative practices. With a substantial portion of childhood hearing loss being preventable, integrating health promotion activities is vital (WHO, 2021a; WHO, 2021b). There's a call for enhancing caregiver knowledge about preventable ear and hearing conditions through robust health education programs, which aligns with broader public health goals of reducing the prevalence of hearing loss in children (Kaspar et al., 2021).

Caregiver reasons for follow-up default

The observed discrepancy in attendance rates between second hearing screenings at preschools and follow-up appointments at public healthcare facilities highlights the challenges inherent in accessing hearing healthcare in LMICs. This discrepancy reinforces the value of decentralized, community-based models in promoting access to hearing healthcare, echoing the success of similar strategies in existing studies (Suen et al., 2019; Eksteen et al., 2019; Kuschke et al., 2020).

Despite free public health services at the point of care in the Western Cape, many families in this study were unable to attend follow-up appointments due to barriers and logistic constraints. The telephonic surveys provided a deeper exploration of these barriers revealing a willingness among caregivers to seek care for their children that was counteracted by various factors, including work commitments, travel costs, long wait times at healthcare facilities requiring a full day's commitment for what

may be only a one-hour appointment. Olusanya (2015) reported similar reasons for follow-up default in an NHS screening program in Nigeria, mainly due to logistic constraints, cost issues, poor infrastructure, and lack of appropriate patient data management and tracking systems. Non-attendance can result in inefficient use of healthcare provider time and delays the identification, diagnosis and timeous intervention of healthcare conditions which has significant long-term consequences for children and their families, including poorer health and quality of life, decreased rates of school participation and an increased risk of poverty (WHO, 2021a; Suen et al., 2019).

The significant communication issues regarding the referral process and follow-up appointments present a significant barrier to accessing ear and hearing services for children. This aligns with findings from previous studies in Malawi (Bright et al., 2017a) and South Africa (Scheepers et al., 2014) that investigated reasons for low uptake of referrals to ear and hearing services for children. Misunderstandings and confusion about the screening outcomes and referral process were identified as key contributors to the non-uptake of referrals (Scheepers et al., 2014; Bright et al., 2017a). Even with various communication methods utilized for reminders, the complexity of the healthcare system's navigation remains a significant obstacle. In addition, a portion of caregivers did not attend follow-up appointments because they had relocated (21%), a factor attributed to missed medical appointments in previous South African studies of up to 30% due to the migratory patterns of the population (Magadzire et al., 2017).

The role of CHWs and screeners in providing clear and compelling explanations about the importance of follow-up care cannot be overstated, though their time constraints pose challenges. Interestingly, a study by Olusanya (2009) revealed that

the reasons contributing to low follow-up rates included minimal prompting from screeners or caregivers not being traceable. Effective communication with caregivers requires employing dedicated personnel (trained CHWs and screeners) to convey the importance of healthy ears and hearing, provide actionable recommendations and create a supportive environment for caregivers. Caregivers should also be encouraged to take responsibility for their child's medical appointments by contacting and rearranging appointments within their local area. There is evidence that health education interventions (such as structured group education, or use of pictorial cards) delivered by CHWs can have positive effects on uptake of health interventions for children (Bright et al., 2017b).

The global COVID-19 pandemic highlighted significant challenges in accessing ear and hearing services, leading to many appointment cancellations as these services were deprioritized and not considered essential health services. This emphasizes the need for flexible scheduling and prioritization protocols for ear and hearing services, where strategies could be implemented to catch up on missed appointments. Despite these challenges, it is noteworthy that many caregivers recognized the negative impacts of hearing loss on a child's development. However, there was a discrepancy between this awareness and action, as evidenced by the proportion of caregivers interested in rescheduling. Previous studies revealed that the reason for non-attendance was due to lack of information and awareness about childhood hearing loss (Scheepers et al., 2014; Bright et al., 2017a; Swierniak et al., 2021). It reinforces the necessity of robust education and outreach efforts to inform and motivate caregivers. There is an essential need for effective communication strategies for healthcare professionals and a call for future studies to delve into culturally appropriate hearing screening approaches and to examine how cultural,

socioeconomic, and demographic factors shape caregiver responses to children's hearing concerns.

CONCLUSION

This study demonstrates the effectiveness of community-based hearing screenings facilitated by CHWs in low-income African communities, reflecting strong caregiver support and highlighting the need for culturally relevant communication. While early detection and intervention are crucial for mitigating the long-term negative effects on a child's communication abilities, academic achievements, behaviour and social inclusion, significant challenges in follow-up attendance at healthcare facilities must be addressed. The insights gained from caregiver feedback call for healthcare systems to enhance accessibility and communication to ensure the success of these programs. Moving forward, prioritizing caregiver concerns, promoting accessibility, and providing culturally sensitive education are essential to improving outcomes. The study's findings advocate for the broader implementation of such community-focused initiatives integrated with existing health systems, while also highlighting the importance of overcoming systemic barriers to optimize their efficacy and impact on children's hearing health in LMICs.

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Author contributions

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Conflicts of interest

De Wet Swanepoel has a financial relationship with the hearX Group that includes equity, potential royalties and consultation. The other authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Data availability statement

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

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