Outcomes of children with sensorineural hearing loss fitted with binaural hearing aids at a pediatric public hospital in South Africa

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Abstract

Objective: To describe hearing aid outcomes for children with bilateral sensorineural hearing loss (SNHL) at a pediatric public hospital in South Africa in terms of daily use and oral/aural performance.

Materials and methods: Retrospective review of clinical data and caregiver reported outcomes of children aged 0-13 years with bilateral SNHL at one-month and three-months post-fitting. Oral/aural performance was measured by the *Parents' Evaluation of Aural/Oral Performance of Children* (PEACH) questionnaire. Multiple linear regression was used to evaluate factors associated with hearing aid use. Thematic analysis was applied for qualitative caregiver-reported outcomes.

Study sample: Sixty-eight children with confirmed bilateral SNHL who were fitted with binaural air-conduction hearing aids at Red Cross War Memorial Children's Hospital in Cape Town, South Africa, between January 2017 and December 2019.

Results: Average daily hearing aid use increased significantly ($p < 0.05$) from one-month (5.0; 3.0 SD; range 0.3 - 14.0) to three-months post-fitting (5.9; 3.4 SD; range 1.1 – 16.8). Average PEACH scores were higher in Quiet (73.4%) than in Noise (69.6%). More than half (52.2%) of children required review based on their overall percentage PEACH scores. Higher average daily hearing aid use was significantly associated with higher overall PEACH scores

($p < 0.05$). Neuro-typically developing children had significantly higher hearing aid use than children with additional disabilities ($p < 0.001$). Qualitative caregiver feedback revealed themes pertaining to advantages and barriers to hearing aid use.

Conclusion: Outcomes of children with SNHL fitted with binaural hearing aids at a pediatric public hospital in South Africa demonstrated increased average daily hearing aid use from one-month to three-months post-fitting. Aural/oral performance was typical for one in two children. Children with additional disabilities had significantly poorer hearing aid use and aural/oral performance requiring more support for this vulnerable group to realize sufficient benefit from hearing aid use.

Keywords

Hearing aid outcomes; sensorineural hearing loss; data logging; PEACH questionnaire

Introduction

Childhood hearing loss is a global challenge and the second most prevalent developmental disability [1]. Hearing loss affects approximately 15.5 million children under the age of five years worldwide [1] and is the third largest cause of global Years Lived with Disability [2]. The estimated global cost within the education sector for providing support to children with hearing loss (aged 5-14 years) is 27 billion USD annually [3]. Approximately 95% of children with developmental disabilities reside in low- and middle-income countries (LMICs) [1]. In sub-Saharan Africa alone, an estimated 10.3 million children under the age of 10 years suffer from permanent disabling hearing loss [4].

Due to poor hearing healthcare infrastructure and limited new-born hearing screening programmes, less than 10% of the more than one million babies born annually in South Africa have access to hearing screening services [5, 6]. The initiation of early intervention services for children with hearing loss is often delayed in resource-constrained settings where widespread poverty is rife [7]. Childhood hearing loss without intervention impedes normal acquisition of spoken language [8] placing children at increased risk of poor academic performance, social- and emotional developmental delays, and behavioral disorders [8]. Children with more severe hearing losses demonstrate poorer literacy than their normal-hearing peers with educational levels that are generally lower [9, 10]. Without appropriate and timeous intervention, the negative consequences of childhood hearing loss continue into adulthood with significant lifetime costs in loss of productivity [8, 3].

Management of childhood hearing loss involves prevention where possible, early identification, accurate diagnosis, fitting of appropriate hearing technology, and auditory rehabilitation. Children with hearing loss who reside in rural or underserved areas typically receive hearing technology (such as hearing aids or cochlear implants) much later when compared to children who reside in urban areas [11]. In sub-Saharan Africa there is typically less than one hearing health professional to every million people, which severely limits capacity to deliver services for timely detection and intervention [12]. Along with other challenges including poor awareness and lacking infrastructure the result is that more than 80% of hearing aid needs are not met in LMICs [13, 3].

It is now universally agreed that to ensure optimal outcomes for children with hearing loss, the earliest possible access to appropriate intervention is required [3]. A primary component of intervention for children with hearing loss is to provide access to sound by means of hearing aids or other assistive technologies [14]. The main aim of fitting hearing aids for children is to improve functional listening skills and to promote participation in hearing-specific communication situations [14]. Hearing aid outcomes are typically described by obtaining aided speech perception results, feedback from parent- and teacher questionnaires, as well as documenting hearing aid use via data-logging tracker software in the device [14, 15]. Hearing aid outcomes assessment is an important part of evidence-based clinical practice [14, 15]. Accurate description of a child's auditory behaviour and outcomes with hearing aid use is important to make rehabilitative decisions, such as identifying areas that require auditory training, determining the effectiveness of the hearing aids and rehabilitation programmes, and evaluating the appropriateness of educational placement and academic performance [16]. Measuring hearing aid outcomes is a complex process because no single measurement exists to determine outcomes on the multidimensional aspects of auditory behaviour in children [17]. This process becomes even more complicated due to barriers including a lack of standardised outcome assessment tools in a multilingual and multicultural context within resource constrained LMIC typical of most South African children.

Consistent hearing aid use is crucial for children to benefit from early intervention programmes and is the foundation for the development of spoken language [18, 19]. Children with hearing loss who consistently use optimally fitted hearing aids develop better vocabulary, grammar, and oral language [20, 21]. Understanding caregiver-related challenges with hearing aid management and potential factors that predict hearing aid use can help professionals to better support families of children with hearing loss so that they may reach equivalent auditory-based outcomes as their hearing peers [18, 22]. Limited evidence is available regarding typical outcomes for children with hearing loss in South Africa and potential contributing factors [23]. Children with hearing loss require specialist interventions; therefore, describing their outcomes with hearing aids are important to plan healthcare services, educational support, amplification, and intervention services [14]. The aim of this study was to describe hearing aid outcomes and oral/aural performance in South African children with bilateral sensorineural hearing loss (SNHL) accessing the public health care system.

Materials and methods

The study was approved by the University of Pretoria Research Ethics Committee of the Faculty of Humanities (HUM024/0419), the University of Cape Town Human Research Ethics Committee (365/2019), the Red Cross War Memorial Children's Hospital (RCWMCH) Ethics Committee (RCC203), and the Western Cape Health Research sub-directorate (WC_201906_023).

Setting

Red Cross War Memorial Children's Hospital (RCWMCH) is the only dedicated pediatric tertiary-level academic hospital in sub-Saharan Africa and serves as a central referral hospital for patients across the entire Western Cape who require specialised healthcare services. The Audiology Department at RCWMCH provides specialist diagnostic audiology and intervention services to children from birth to 13 years from the public health care sector.

Study design

A retrospective review of clinical and caregiver reported data from children aged 0-13 years with bilateral SNHL who were fitted with binaural hearing aids between January 2017 and December 2019 at RCWMCH was conducted.

Study population and sampling strategy

Purposive sampling was used to identify all children aged 0-13 years with a diagnosis of confirmed symmetrical bilateral SNHL of >20 dB HL averaged across 0.5 kHz, 1 kHz and 2 kHz, with an air-bone gap <15 dB HL averaged over 0.5 kHz, 1 kHz, and 2 kHz, and who were fitted at RCWMCH with binaural air-conduction hearing aids between January 2017 and December 2019.

Data collection procedures

Participants were identified retrospectively via a departmental electronic database and their demographic information was recorded. Independent variables that could influence hearing aid use were identified via the same database. Behind-the-ear air-conduction hearing aids from the same company was fitted for all the participants. All hearing aids were verified at the initial fitting by calculating the aided audibility of speech through the hearing aid as measured with probe microphone measures [15]. Real-ear aided response (REAR) probe microphone measurements were done, where possible. In cases where REAR measurements could not be obtained, simulated REAR measurements in a coupler using measured or age-appropriate real-ear to coupler difference (RECD) were obtained [15].

The average daily hearing aid use (h/day) was documented by capturing data logging information stored in each hearing aid at one-month and three-months post-fitting intervals. The hospital files of children who attended their one-month hearing aid fitting follow-up appointment were reviewed to obtain hearing aid validation information as measured by the *Parents' Evaluation of Aural/Oral Performance of Children* (PEACH) questionnaire.

The PEACH rating scale is a questionnaire that assesses the listening performance of children in a range of communication situations in quiet and background noise [24]. The PEACH rating scale was developed as an abbreviated version of the PEACH Diary [22] and

has been validated on normal hearing children [24]. The PEACH rating scale requires parents to rate their child's performance in different listening situations on a scale from 0 ("Never") to 4 ("Always"). The PEACH rating scale includes 13 questions, including one question about device use, one question about tolerance for loud sounds, six questions about quiet listening situations, and five questions about listening in background noise. A percentage score for Quiet, Noise and Overall is calculated by adding the numerical values for the response to each question and dividing it by the total number of potential points for each subscale [24]. The total percentage score for each subscale is then used to plot performance with hearing aids in Quiet, Noise, and Overall, to indicate whether performance is typical, whether possible review is indicated, or whether further review is indicated.

The PEACH questionnaire in the original English format was issued to caregivers in hard-copy format at the initial hearing aid fitting. The managing audiologist scored and recorded the questionnaire at the one-month post-fitting follow-up appointment. Caregivers were encouraged to observe their children's behaviour in the month following initial hearing aid fitting, and to complete the PEACH questionnaire in the week prior to their one-month follow-up appointment. In cases where caregivers were not proficient in reading and writing in English, the PEACH questionnaire was administered interview-style by the managing audiologist. There is a section for additional comments at the end of the PEACH questionnaire, therefore qualitative written caregiver-reported outcomes at the one-month post-fitting appointment were also obtained and recorded from returned PEACH questionnaires for qualitative thematic analysis.

Data analysis

Data were imported into Microsoft Excel 2016 (Microsoft Corp, Redmond, WA) and analysed using R statistical computing programme (Version 4.1). Quantitative analysis of data included descriptive and inferential statistics. Student's *t*-test was used to compare average hearing aid use (h/day) at one-month and three-months post-fitting, average hearing aid use between subgroups of children with additional disabilities and neuro-typically developing children, as well as average hearing aid use between groups of children with *Typical Overall* PEACH scores and those who required review. Hearing aid fitting software automatically averages hearing aid use between the previous and current date every time the hearing aid is coupled to the programming software.

Categorical and continuous variables were identified from the departmental electronic database. Continuous variables (age at diagnosis and hearing aid fitting) were converted into categories (*Toddler* [0-2 years], *Pre-school* [3-6 years] and *School-going* [> 6 years]). Analyses of variance (ANOVA) (α level = 0.01) was used to determine whether there was a bivariate relationship between the outcome variable (average daily hearing aid use) and the independent variables. Subsequently independent categorical variables that were significantly associated with hearing aid use (dependent variable *Y*) were included in two multiple linear regression models (one-month and three-months post-fitting). Binary indicators (1;0) were applied to use these categorical variables in the multiple linear regression models. Multiple linear regression was performed to examine the simultaneous effect of multiple predictors on *Y*. Hearing aid use for the right and left ears differed

minimally for all participants, therefore the ear with the highest data logging was selected for statistical analyses. For all analyses, the level of significance was set at .05 ($p < 0.05$).

Qualitative thematic analysis was applied for caregiver reported outcomes written in the additional comments section of the PEACH questionnaire. The caregiver reported written text was reviewed by the first author and themes were extracted, which were subsequently checked by the co-authors to establish a final set. These themes with examples were grouped into advantages of and barriers to hearing aid use.

Results

Sixty-eight children with bilateral SNHL who were fitted with binaural hearing aids between January 2017 and December 2019 were included in the study sample. Characteristics of the study population is presented in Table 1. More than half of the participants (52.9%) had congenital/early onset hearing loss, while most participants (38.2%) had a moderate degree of hearing loss (n=68). The mean age of suspicion of hearing loss for participants with congenital/early onset SNHL was 23.9 months (16.3 SD; range 1-72), the mean age of diagnosis was 31.6 months (22.7 SD; range 2-72) and the mean age at hearing aid fitting was 32.5 months (23.9 SD; range 3-74) for these children (n=36). There was approximately one-month delay between hearing loss diagnosis and hearing aid fitting for the congenital/early onset group. More than a quarter (26.5%) of children in this sample had additional disabilities (n=68).

Table 1: Characteristics of study population (n=68)

	% (n)
Gender	
Male	45.6 (31)
Female	54.4 (37)
Household income	
H0 (Formally unemployed)	8.8 (6)
H1 (0 USD – 400.62 USD per month*)	70.6 (48)
H2 (400.62 USD – 1430.84 USD per month*)	13.2 (9)
H3 (>1430.84 USD per month*)	7.4 (5)
Home language	
English	50.0 (34)
Afrikaans	11.8 (8)
Xhosa	32.3 (22)
Other	5.9 (4)
Language of instruction	
English	55.9 (38)
Afrikaans	4.4 (3)
Xhosa	3.0 (2)
South African Sign Language	27.9 (19)
Augmentative and alternative communication	8.8 (6)
Educational setting	
Mainstream school	23.5 (16)
Inclusive mainstream school	4.4 (3)
Signing school	20.6 (14)
Hearing impaired skills school	13.2 (9)
Special needs school	17.7 (12)
Not of school-going age	20.6 (14)
Age at diagnosis of hearing loss in months	
Total sample (n=68)	
Mean (SD)	54.9 (34.3)

Range	2-156
Congenital/early onset (n=36)	
Mean (SD)	31.6 (22.7)
Range	2-72
Age at hearing aid fitting in months	
Total sample (n=68)	
Mean (SD)	57.0 (34.2)
Range	3-157
Congenital/early onset (n=36)	
Mean (SD)	32.5 (23.9)
Range	3-74
Onset of hearing loss	
Congenital/early onset	52.9 (36)
Acquired	30.9 (21)
Unknown	16.2 (11)
Additional disabilities**	
One or more additional disability	26.5 (18)
No additional disabilities	73.5 (50)
Degree of hearing loss***	
Mild (16 - 40dBHL)	20.6 (14)
Moderate (41 - 60dBHL)	38.2 (26)
Severe (61 - 80dBHL)	14.7 (10)
Profound (> 80dBHL)	26.3 (18)

dBHL – decibels hearing level

*Exchange rate of 1 USD = R14.56 (South African Rand/ZAR)

**Additional disabilities included cerebral palsy, syndromes, neuro-developmental delay

***WHO classification of degree of HL based on the better ear 4FPTA [26; 27]

Hearing aid use

Data logging information was obtained for 61 participants at the one-month follow-up interval, and for 51 participants at the three-month follow-up interval. Missing data was accounted for by children not attending their one- or three-month follow-up appointments, or audiologists not recording data logging information at the follow-up sessions. Mean hearing aid use (h/day) at one- and three-month post-fitting is depicted in Table 2 for the right and left ears respectively. There was a significant increase in mean hearing aid use at three-months post-fitting (p = 0.030). Average daily hearing aid use was calculated for the subgroup of children with additional disabilities (n=18) and compared to the neuro-typically developing children in this sample (n=33) at the three-month follow-up interval. Neuro-typically developing children had significantly higher (p < 0.001) hearing aid use of 6.5 h/day (3.1 SD; range 1.2 – 14.2) than children with additional disabilities with 2.8 h/day (1.4 SD; range 0.3 – 5.2). Average daily hearing aid use was also calculated for an additional two subgroups of children at the three-month follow-up interval: those whose language of instruction was South African Sign Language (n=19) and those with returned PEACH scores (n=23). Average daily hearing aid use for the South African Sign Language sub-group was 4.0 h/day (2.2 SD; range 1.1 – 9.1), and for the PEACH subgroup 6.6 h/day (3.1 SD; range 1.5 – 14).

Table 2: Hearing aid use at one-month (n = 61) and three-months (n = 51) post-hearing aid fitting

Hearing aid use	Right ear (h/day)	Left ear (h/day)	Average right and left ear (h/day)	p-value
1-month post-fitting				
Mean (SD)	5.0 (3.0)	4.9 (2.9)	5.0 (3.0)	
Range	0.3 -14.0	0.3 -12.3	0.3 - 14.0	0.030
3-month post-fitting				
Mean (SD)	5.9 (3.4)	5.8 (3.3)	5.9 (3.4)	
Range	1.1 -16.8	1.1 -16.3	1.1 - 16.8	

Factors associated with hearing aid use

Eight categorical variables (gender, aetiology of hearing loss, onset of hearing loss, additional disabilities, household income, home language, language of instruction, degree of hearing loss) and two continuous variables (age at diagnosis, age at hearing aid fitting) were identified from the departmental electronic database. After continuous variables were converted into categories, ANOVA (α level = 0.01) significantly associated six of the ten potential independent categorical variables with hearing aid use (dependent variable *Y*), namely gender, onset of hearing loss, additional disabilities, household income, language of instruction and degree of hearing loss (Table 3). These six independent categorical variables were included in two multiple linear regression models (one-month and three-months post-fitting).

Table 3. Factors associated with hearing aid use

Independent variable	Parameter	n	Hearing aid use (h/day)		ANOVA (α = 0.01)	Coefficient
			Mean	SD (range)		
Gender	Male	31	5.1	3.1 (0.2 – 12.1)	<0.01	-0.379
	Female	37	5.9	3.3 (0.3 – 14.0)		0
Aetiology of hearing loss	Syndromic	24	2.6	1.2 (0.7 – 4.9)	0.5	N/A
	Infectious	15	3.1	1.4 (1.1 – 5.2)		
Onset of hearing loss	Congenital	36	4.2	2.0 (1.8 – 11.6)	<0.01	-0.092
	Acquired	21	5.8	3.1 (1.1 – 12.1)		0
Additional disabilities	No additional disabilities	50	6.5	3.1 (1.2 – 14.2)	<0.001	0
	Additional disabilities	18	2.8	1.4 (0.3 – 5.2)		-2.335
Household income	Low (<400.62 USD per month)	54	4.5	3.3 (0.8 – 10.2)	<0.01	0
	High (>400.62 USD per month)	14	7.1	2.1 (3.7 – 12.4)		2.435
Home language	English	34	4.8	2.2 (1.2 – 11.2)	0.2	N/A
	Other	34	5.1	3.1 (0.3 – 12.4)		
Language of instruction	Auditory-oral	43	5.2	3.0 (1.2 – 16.8)	<0.01	0
	Visual	25	3.8	2.1 (1.1 – 8.4)		-2.385
Degree of hearing loss	Mild-moderate (16 - 60 dBHL)	40	4.8	3.2 (0.2 – 11.2)	<0.01	0
	Severe-profound (61 - >90dBHL)	28	5.9	3.4 (1.2 – 14.2)		0.667
Age at diagnosis of hearing loss	Toddler (0 – 2 years)	12	5.1	4.2 (1.2 – 16.8)	0.6	N/A
	Pre-schooler (3 – 6 years)	32	5.5	3.5 (0.8 – 12.4)		
	School-going (> 6 years)	15	5.0	2.1 (1.5 – 9.4)		
Age at hearing aid fitting	Toddler (0 – 2 years)	12	5.1	4.2 (1.2 – 16.8)	0.5	N/A
	Pre-schooler (3 – 6 years)	36	5.6	4.3 (1.0 – 12.4)		
	School-going (> 6 years)	17	5.2	2.2 (1.6 – 9.4)		

Based on the *p*-value of all the independent variable's coefficients, multiple linear regression models were not able to significantly predict factors that influence hearing aid use at the one-month and three-month post-fitting follow-up interval respectively (*p*-value = 0.34 and 0.51).

Caregiver reported outcomes

Caregivers observed their children's behaviour in the month following initial hearing aid fitting and completed the PEACH questionnaire in the week prior to their one-month follow-up appointment. PEACH questionnaires were returned by caregivers for 23 participants at the one-month follow-up appointment. Most children (78.3%; n=18/23) reportedly wore their hearing aids either always or often. Loudness discomfort ratings indicated that most children (87%; n=20/23) were never or seldom upset by loud sounds. Figure 1 depicts the frequency distribution of caregiver-reported hearing aid use and loudness discomfort ratings for 23 participants. Mean PEACH scores were higher in Quiet (73.4%) than in Noise (69.6%) (Table 4). Approximately half of the participants (47.8%; n=11) showed typical overall performance based on their PEACH percentage scores (Figure 2). Significantly higher hearing aid use ($p < 0.05$) of 7.0 h/day (2.1 SD; range 3.9 – 11.2) was recorded for the *Typical Overall Performance* group (n=11) when compared to the groups who required review (6.1 h/day; 3.9 SD; range 1.5 – 12.4) (n=12).

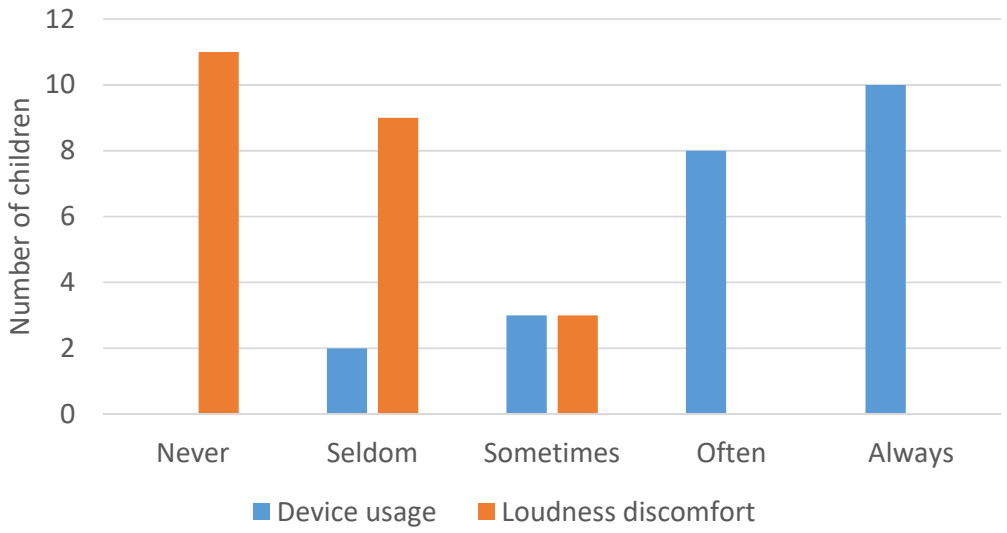

Figure 1. Caregiver reported device use and loudness discomfort

Table 4: Mean PEACH scores for Quiet, Noise and Overall (n=23)

Percentage score in Quiet (mean (SD); range)	73.4 (23.0); 25-100
Percentage score in Noise (mean (SD); range)	69.6 (23.0); 15-100
Percentage score Overall (mean (SD); range)	71.7 (29.0); 5-100

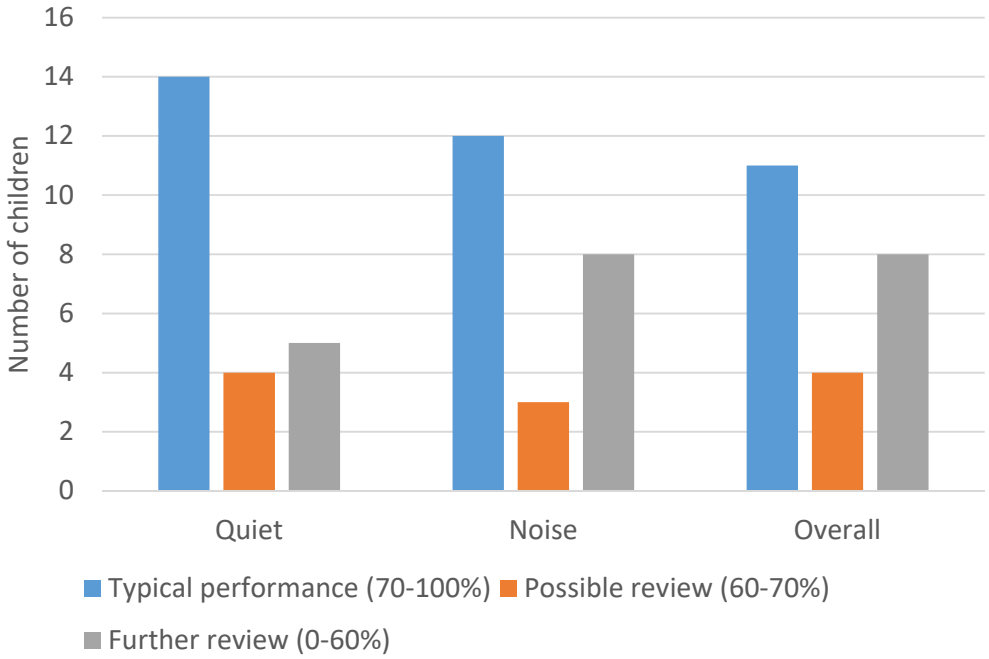

Figure 2. PEACH indication for Quiet, Noise and Overall scores (n=23)

Written feedback on the PEACH questionnaire in the *additional comments* section was obtained from 12 caregivers. Seven themes emerged from analysis of the qualitative data and were grouped into advantages and barriers to hearing aid use (Table 5).

Table 5: Thematic analysis of additional written feedback from caregivers on the PEACH questionnaire (n=23)

	Theme	Examples
Advantages of hearing aid use	Listening	"She used to put volume of TV loud before, now she playing television in soft volume" "The sound of water coming from a tap can be heard clearer" "It help him to concentrate more than he used to" "I can see a huge improvement with her and her response when one calls her or to follow instructions"
	Confidence and enjoyment	"She report it to teacher" "He has noticed the difference in story-time himself (first week already), and is quite proudly wearing the aids with no embarrassment factor at all" "She asks to wear the hearing aids without me reminding her" "Liking is being evidenced by his smiling when wearing them" "She clearly enjoys the sound of her own voice. She won't stop making sounds!" "He is very happy with his hearing aids and loves them"
	Speech production	"I see an improvement with her speech as well, certain sounds that she couldn't pronounce before is now way clearer" "When she speaks her tone will be softer when the hearing aids are in and her tone will be louder when she removes it"
	Social interaction	"I can see a difference in my son's communication, with myself and others around him" "He now involves himself in the community with his friends"
Barriers to hearing aid use	Bullying	"A classmate threw a book against her ear" "Children grab it out of his ear and laugh"
	Hearing aid retention	"During the first days of using the hearing aids, he used to dislike them. He would any and by all means have them removed" "Due to 'rough and tumble' circumstances at after-school care, we allow him to leave them out" "The left hearing aid is getting loose often" "We not succeeding with it and it is difficult to put in his ears"
	Medical aspects	"He has complained of itchy ears often. Hearing aids are removed to itch and then replaced" "Sometimes his ears leak and he can't wear them"

Discussion

This study aimed to describe hearing aid outcomes for children aged 0-13 years with bilateral SNHL in a low-resourced context. Daily average hearing aid use of 5.9 h/day at the three-month follow-up interval for this study sample compared with average estimates for children of 5-8 h/day [18], but fell short of the recommended 10 hours per day for optimal language development [21]. There was a significant increase in hearing aid use at the three-month follow-up interval when compared to the initial one-month follow-up. Findings from a previous study on predictors of change in hearing technology use in Australia showed that consistent use was established for 62% of children within the first year of amplification, and 71% of children at three years post-fitting [19]. A recent South African study on predictors for hearing technology use found a higher average of hearing device use (9.4 h/day) over an eight-year period [28].

The average age of hearing loss diagnosis for children with permanent congenital or early-onset hearing loss was 31.6 months (n=36), which highlights the consequences of limited new-born hearing screening programmes in the public sector of South Africa [5,23]. Delayed diagnosis of childhood hearing loss results in delayed initiation of intervention, which leads to poorer speech-language and academic outcomes [10].

Lower household income was associated with decreased hearing aid use in this sample. Nearly 80% of children in this study sample came from low-income households (<400.62 USD per month). In a recent South African study on hearing technology use in children, it was reported that children who required subsidized batteries due to poor socio-economic circumstances had reduced hearing technology use compared to those who were able to self-procure [28]. The setting for the current study was a centralized tertiary pediatric hospital, where most patients had to travel long distances to access audiological services. Lack of access to follow-up audiological services (such as collecting hearing aid batteries and hearing aid repairs) could have contributed to the poorer average daily hearing aid use in this sample. In a 2015 longitudinal study investigating hearing technology use for children at age three years, higher socio-economic status was associated with increased device use [19]. Low-income households often have less access to resources in terms of support-structures and experience more pressing needs (such as food-security) than hearing aid maintenance [22].

In the current study, only 17.6% of children were placed at an education facility where audiology services were available onsite (inclusive mainstream and hearing-impaired skills schools in the Western Cape). Education settings where onsite audiologists are available increase access to technology-related support and rehabilitation, which contributes to increased hearing aid use [28]. One in five (20.6%) children in this study were not old enough to attend formal schooling and were either looked after by family members at home or attended a crèche. Hearing aid use for children in daycare settings have been linked to challenges with consistent use reported for 50%, 40%, and 70% of 6, 12, and 24-month old's respectively [20]. An auditory-oral mode of communication was reported as a significant predictor of increased hearing technology use in children in a recent sample from the Western Cape Province of South Africa [28]. Nearly one-third (27.95%) of children in the current study used South African Sign Language as primary mode of communication. Average daily hearing aid use in this subgroup was four hours, suggesting reduced necessity

of auditory access through hearing aids for learning. Decreased hearing aid use in children is associated with limited access to healthcare services [22], lack of perceived benefit for learning through audition [18] and contexts where the use of hearing technology is not enforced [20].

Most caregivers (78.3%) for the PEACH subgroup (n=23) reported that their children wore hearing aids always or often, however, the average data logging hours in this subgroup was 6.6 h/day. Parents frequently over-estimate hearing aid use when compared with data logging information stored in the hearing aid [20]. Nearly half of the children (47.8%) showed typical overall performance based on their percentage PEACH scores. Significantly higher hearing aid use of 7.0 h/day was recorded for the *Typical Overall Performance* group when compared to the group who required review. In a 2015 study on hearing aid and cochlear implant use in young children, higher PEACH scores were associated with higher device use scores [19]. More than half (52.2%) of children in this study whose caregivers completed the PEACH required review based on their overall PEACH percentage scores. PEACH scores in Quiet (73.4%) were higher than in Noise (69.6%). Noisy environments have a negative impact on the listening and learning opportunities for children with hearing loss, both at home and in educational settings [29]. Improving the signal-to-noise-ratio for children with hearing loss should be an important goal to mitigate the negative effect of noisy environments [29]. One in four (26.5%) children in the current study presented with additional disabilities, which was associated with significantly lower hearing aid use, and likely contributed to poorer functional listening performance [20]. Audiologists who provide intervention for children with additional disabilities should work collaboratively within a multi-disciplinary team to find innovative solutions for increased hearing aid use and functional listening outcomes.

Qualitative caregiver reported feedback revealed themes of perceived advantages of hearing aid use, and barriers to hearing aid use. Hearing healthcare professionals play an important role in helping parents to address challenges relating to the ongoing management of their child's hearing loss [18], so that consistent hearing aid use can be achieved. In a previous study regarding pediatric hearing aid use, caregiver challenges regarding navigating daily hearing aid management was associated with hearing aid use [18] and should be addressed continuously by the managing audiologist. Caregivers noticed and reported benefits such as improved confidence and enjoyment of hearing aid use, better speech production, and increased social interaction within one month after fitting. Caregiver perception of hearing aid benefit is an important indicator for hearing aid use [18]. Caregiver-reported barriers included difficulty with keeping the hearing aids in their children's ears. Solutions such as retention caps for younger children in situations like traveling in car seats could alleviate some of the difficulty caregivers experience with facilitating hearing aid use [28].

The sample size in the current study was limited and therefore regression models were likely underpowered to identify relationships between independent variables and hearing aid use. Bigger sample sizes could contribute to the knowledge base on predictors of hearing aid use in children within a low-resourced context [28]. The wide age distribution in

this sample had an impact on generalizing findings. Future studies on hearing aid outcomes in LMICs should consider age-group-specific distribution pockets. Although there was a significant improvement in average hours of hearing aid use at the three-month follow-up interval, outcomes were only recorded at one- and three-months post-fitting. Future longitudinal data on hearing aid use in the LMIC context will be valuable to determine whether hearing aid use increases over a longer period, so that predictors and barriers to hearing aid use can be described more comprehensively.

Conclusion

Outcomes of children with SNHL fitted with binaural hearing aids at a pediatric public hospital in South Africa demonstrated sub-optimal average daily hearing aid use of 5.9 hours, which increased from month one to three. At-risk groups like children from low-income households and those with additional disabilities require more support to ensure optimal hearing aid use. Aural/oral performance was typical for nearly half of the children in this sample, and higher hearing aid use resulted in better functional listening performance. Caregivers report hearing aid benefit within one month of fitting. Hearing healthcare practitioners should empower caregivers and children to participate actively in their intervention to identify potential address barriers to hearing aid use early on.

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