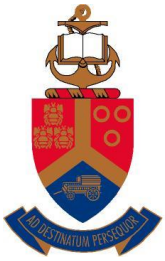


UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

PREDICTORS OF HEARING TECHNOLOGY USE IN CHILDREN WITH HEARING LOSS

Surida Booysen

A dissertation submitted in fulfilment of the requirements for the degree

MA (Audiology) in the Department of Speech-Language Pathology and Audiology

University of Pretoria

Faculty of Humanities

Supervisor: Prof De Wet Swanepoel

Co-supervisor: Dr Talita le Roux

April 2021

Surida Booysen

MA (Audiology) student

Department of Speech-Language Pathology and Audiology

University of Pretoria

Pretoria

South Africa

suridab@gmail.com

ACKNOWLEDGEMENTS

First and foremost, all the glory belongs to my Heavenly Father. I praise you for your overwhelming grace and faithfulness. You lead, comfort, teach, protect, and strengthen me every day; You are my reason. Almighty God, you are the only variable in life and science for whom we do not need predictors or forecasts of the future. You are an everlasting rock and fortress, my God in whom I trust. "*For everything comes from Him and exists by His power and is intended for His glory. All glory to Him forever". Rom 11:36 (NLT).*

De Wet and Talita. I could not have asked for better direction; you are the best! It has been an honour to complete this project under your guidance. Thank you for your excellent supervision and patience, as well as the invaluable insights and wealth of experience you shared with me. I especially appreciate your considered feedback and ability to guide me to think further, question more and argue clearer.

Andries, thank you so much for your assistance with the statistical analysis of this research project. I appreciate your clear direction and ability to help me make sense of the results.

My beloved family and friends. God provided the light on this journey, De Wet and Talita had the roadmap, but you were my companions. Thank you for all the encouragements and interest, your continuous prayers, and understanding that a small project could, in fact, last ages. I am blessed and thankful to have every one of you in my life.

Lastly, but no less importantly, I would like to acknowledge the children and their families from the Carel du Toit Centre whose data made this project possible. Whoo-hoo to each of you! You are brilliant, feisty, strong, kind, gorgeous, successful, determined, funny and unique. You do not need predictors; there is no question that you will continue to beat the odds!

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

PLAGIARISM DECLARATION

Student name:	Surida Booysen
Student number:	27413099
Degree:	Masters in Audiology
The title of the work:	Predictors of hearing technology use in children with hearing loss

I declare that this is my own original work. Where secondary material is used, it has been carefully acknowledged and referenced in accordance with university requirements.

I understand what plagiarism is and am aware of university policy and implications in this regard.

Surida Booysen 27 April 2021

CONTENTS

ABSTRACT

Prescribing hearing technology (HT) to children with hearing loss is based on the expectation that it will improve auditory-based communication outcomes, literacy, occupational prospects, and psycho-social wellbeing. The desired effect, however, can only be achieved if appropriate HT is used optimally to foster consistent, cumulative auditory experiences comparable to peers with normal hearing. Therefore, a better understanding of the factors that influence HT use in children with hearing loss is necessary to guide hearing healthcare services and facilitate auditory-based outcomes. This study aimed to identify and describe predictors of daily HT use in children with hearing loss. A retrospective review of clinical records collected data, including demographic, family, intervention, socio-economic, audiology-related, and HT information. The study sample included 505 children (<11 years of age), fitted with hearing aids (HAs), cochlear implants (CIs), and bone conduction hearing devices (BCHDs), and enrolled in a South African auditory-oral intervention program between 2010 and 2018. Results demonstrated an average HT use of 9.4 hours a day for the entire sample. Multiple regression analyses were performed to identify predictor variables that influenced HT use. From the 42 variables included in the retrospective dataset, the bivariate analyses yielded 31 potential predictor factors. The final general linear model (GLM; p <.01, R^2= 0.605) identified 10 interacting factors that were significantly associated with increased HT use in children. Intrinsic predictors of increased HT use included a more severe degree of hearing loss, older ages at diagnosis and initial HA fitting, and older chronological age. Extrinsic predictors included the child's ability to independently use HT, at least one CI as part of the HT fitting, coordinated onsite audiological management, self-procured batteries, auditory-oral communication mode, and regular caregiver intervention attendance. Six of the 10 predictors identified were novel and previously undescribed in the literature, including CI recipiency, independent HT use, caregiver intervention attendance, older ages at diagnosis and initial HA fitting, and self-procured batteries. In conclusion, the average HT use for this study sample was high but below recommended all-day HT use. Although HT use is a multi-factorial outcome measure, an extensive range of predictive factors was identified that could predict and increase HT use in children. Additionally, four of the predictors, both novel and extrinsic, are malleable, signifying that intervention can change the outcome, namely HT use. These newly described predictors of HT use can contribute to evidence-based intervention services that promote optimal auditory-based outcomes.

keywords: hearing technology use, hearing aids, cochlear implants, bone conduction hearing devices, children, data logging, predictors, childhood hearing loss, retrospective cohort study, general linear model

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

4FPTA	four-frequency pure tone average across 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz
AASM	American Academy of Sleep Medicine
ANSD	auditory neuropathy spectrum disorder
BCHD	bone conduction hearing device
CHL	conductive hearing loss
CI	cochlear implant
dB HL	decibel hearing level
EHDI	early hearing detection and intervention
HA	hearing aid
HHP	hearing hours percentage
HIC	high-income country
HL	hearing loss
HT	hearing technology
LMIC	low- and middle-income country
MHL	mixed hearing loss
NHS	newborn hearing screening
SNHL	sensory-neural hearing loss

1. INTRODUCTION AND STUDY RATIONALE

Children with hearing loss have compromised access to acoustic information, jeopardising competent spoken language, literacy, and neurocognitive development (Dillon et al., 2013; Yoshinaga-Itano et al., 1998). While children with normal hearing have auditory exposure and experiences whenever they are awake, learning spoken language naturally, children with hearing loss have the same inherent capacity to develop auditory-based communication (Flexer & Wolfe, 2020). Therefore audiologists prescribe hearing technology (HT) such as hearing aids (HAs), cochlear implants (CIs), and bone conduction hearing devices (BCHDs) to minimise the effect of childhood hearing loss (American Academy of Audiology, 2013; Health Professions Council of South Africa, 2018; Joint Committee on Infant Hearing, 2019). Consistent use of well-fitted HAs in children with hearing loss (Walker, Holte, et al., 2015) is associated with better vocabulary (Percy-Smith, Hallstrøm, et al., 2018; Tomblin, Oleson, Ambrose, Walker, McCreery, et al., 2020), speech production (Fulcher et al., 2015), and language (Tomblin, Harrison, et al., 2015; Tomblin, Oleson, Ambrose, Walker, & Moeller, 2020); while consistent CI use in children is related to better speech perception (Easwar et al., 2018), receptive vocabulary (Busch et al., 2019), and word recognition (Sharma et al., 2020).

While there is limited evidence about the required quantity of HT use for children with hearing loss (McCreery & Walker, 2017), it is reasonable to propose that HT use should approximate the hearing hours of peers with normal hearing to develop similar spoken language and literacy skills. Accordingly, a better understanding of the factors influencing HT use in children is relevant and can guide audiologists to identify potential barriers and enablers of optimal HT usage (Easwar et al., 2016; McCreery et al., 2015).

HT use can be categorised as either (a) reported by a caregiver or HT user or (b) recorded through an objective measurement called data logging. Caregiver reports of HT use have been chiefly documented using either quantitative labels such as *often* or categorical labels such as *4-8 hours a day*, and overestimation is frequently recognised (Muñoz et al., 2014; Walker et al., 2013; Walker, McCreery, et al., 2015). Furthermore, such subjective reports have other drawbacks, including not reflecting detailed usage information as precise as recorded data logging measures or allowing comparison of results between studies.

In contrast, data logging involves inconspicuous, unobtrusive, and automatic recordings over time (Saunders et al., 2020) and is calculated independent of the user's judgment or memory (Busch et al., 2017). At a minimum, data logging provides an average time that the HT was switched on per

day, collected between two dates and reported in hours and minutes for each hearing device. More recent advancements in HT now also allow logging volume control and program use and can log additional parameters such as the battery life, streaming time, various sound environments, directional microphone settings, and signal-to-noise ratio (Saunders et al., 2020). It can be collected by audiologists whenever HT is connected to a programming computer, generating a new log every time the HT is connected to the programming software. Furthermore, recent eHealth solutions allow data logs to be collected remotely, synchronously, or asynchronously through cloud-based applications (Govender & Mars, 2017). Data logging recordings are robust against response biases and reactive behaviours (Busch et al., 2017) and ideal for controlled observations (Laplante-Lévesque et al., 2014; Saunders et al., 2020). While the strengths of data logging are considerable, it is important to acknowledge that it has limitations too. As each HT manufacturer utilise their own algorithms for data collection, analysis, and sound environment classification, the agreement between and quality of reporting differs between makes and models of HT (Saunders et al., 2020). For example, some cochlear implant manufacturers distinguish between time on-air and coil-offs, translating to a device being on but not working (Busch et al., 2017), whereas others do not. A significant drawback of HA software is that the data logging cannot identify that the HA is in the ear but accidentally turned off, functioning intermittently because of corroded contact points or switched-on, even when not worn. Consequently, because data logging is an automated collection of data, clinical interpretation of the collected data is essential, even more so in the case of children (Muñoz, Larsen, et al., 2019; Saunders et al., 2020).

Data logging has been used extensively in research during the last decade, identifying predictors of HT use (Busch et al., 2019; Jilla et al., 2019; Laplante-Lévesque et al., 2014), investigating the relationship between HT use patterns and outcomes (Easwar et al., 2018; Gagnon et al., 2021; Tomblin, Harrison, et al., 2015; Tomblin, Oleson, Ambrose, Walker, & Moeller, 2020) as well as describing the listening environments of HT users (Busch et al., 2017, 2019; Guerzoni & Cuda, 2017). Cesur et al. (2020) concluded that the measurement of auditory experiences with HT using objective data logging is accurate, consistent, and less time-consuming than subjective measures. Clinically, data logging is a powerful tool that can identify HT use challenges, determine the effectiveness of retention strategies implemented, and support families (Gagnon et al., 2021; Muñoz et al., 2018). Muñoz et al. (2014) encouraged professionals to use data logging collaboratively with families. Family-centred audiology care incorporates both data logging and caregiver report because it fosters family engagement and responsibility, shared power and decision making (Ekberg et al., 2020; English et al., 2017; Joint Committee on Infant Hearing, 2019; Muñoz, Edelman, et al., 2020).

Recently, an alternative manner of categorising HT use in children was proposed. Audiologists can now use hearing hours percentage (HHP) to contextualise data logging (Gagnon et al., 2020; Park et al., 2019). It promotes equating the period the child had access to sound with their HT (as measured through data logging) to the amount of time a child with normal hearing would have heard, otherwise called *hearing hours*. For children with normal hearing, hearing hours are equivalent to awake hours as they typically hear 100% of the time awake. HHP established this awake period of peers with normal hearing as the criterion metric for hearing hours (Gagnon et al., 2021). The American Academy of Sleep Medicine (AASM) published a consensus statement identifying the median sleep hours for different ages (Paruthi et al., 2016). Table 1 recaptured the AASM recommendation for median sleep time (including naps), adding the corresponding median awake or hearing hours accordingly. Using these parameters, HHP is calculated with the following equation: *HHP = average daily HT use/median awake time per age) * 100.* This manner of reporting HT use in children could improve caregivers' understanding and holds promise as it permits children of different ages to be compared with one another.

Table 1. Summary of the recommended sleep time and corresponding awake time, otherwise called hearing hours, for children of different age groups.

Developmental age	Sleep time [a]		Hearing hours
	Median sleep time (hours a day) [a]	Lower-upper sleep recommendations (hours a day) [a]	Median awake time (hours a day)
4-12 months	14	12-16	10
13-35 months	12.5	11-14	11.5
3-5.11 years	11.5	10-13	12.5
6-11.11 years	10.5	9-12	13.5

[a] *The data about awake and sleep time was published in the consensus statement of the AASM* (Galland et al., 2012; Paruthi et al., 2016).

While HT fitting is standardly recommended after the diagnosis of childhood hearing loss (Health Professions Council of South Africa, 2018; Joint Committee on Infant Hearing, 2019), it does not necessarily guarantee full-time HT use. McCreery and Walker (2017) cautioned that all-day HT use in children is neither an achievable nor reasonable goal for families. Previous studies suggested that children generally use their HAs less than 8.5 hours a day (Gustafson et al., 2017; Jones & Launer, 2010; Moeller et al., 2009; Weston et al., 2014) and their CIs less than 10.5 hours a day (Busch et al., 2017; Easwar et al., 2016; Wiseman & Warner-Czyz, 2018). Jones and Launer (2011) collected data logging records from nearly 5000 de-identified HA software files across 60 clinics in the United States. In this large group of children aged ≤18 years, an average of 5.5 hours of daily HA use was recorded, with 40% of the participants demonstrating less than 4 hours of HA use daily (Jones &

Launer, 2011). Another multicentre investigation described average HA use of 8.4 hours a day in 290 (5 months to 7.1 year-olds) American children (Walker, McCreery, et al., 2015). This average daily HA use reported was similar to the findings from a multi-national European study (13 countries with 69 CI centres) of 407 paediatric CI recipients, indicating average CI use between 8.5 to 10.5 hours a day for CI recipients ≤12 years (Busch et al., 2017). Similarly, the recorded average use for a group of ≤18-year-old CI recipients from Canada averaged 9.9 hours a day (Easwar et al., 2016). In contrast, Wiseman and Warner-Czyz (2018) reported a lower average daily use of 7.6 hours a day in 71 paediatric CI recipients (9 months to 16.8-year-old children). Recently, Gagnon et al. (2020) described that the average HHP in 37 paediatric CI recipients (≤5-year-old children) was 63%, ranging from 18% to 117%. In another recent study, 40 toddlers (<3-year-old children) needed 17 months to achieve full-time use (defined as 80%) following CI activation (Park et al., 2019). Considering the average median awake times in children for different age groups captured in Table 1 (Galland et al., 2012; Paruthi et al., 2016), these above-mentioned studies reporting on HT use in children accentuate that children who use HT are not exposed to the same auditory experiences or hearing hours as their hearing peers.

When the goal for children with hearing loss is developing equivalent auditory-based outcomes (Joint Committee on Infant Hearing, 2019; Khoza-Shangase & Kanji, 2021; Walker et al., 2013), a better understanding of the factors that influence HT use is required. Several factors have previously been identified that consistently increased HT use in children, including higher maternal education (Marnane & Ching, 2015), older chronological age (McCreery et al., 2015), younger age at implantation (Easwar et al., 2016), more severe degrees of hearing loss (Marnane & Ching, 2015; Walker, McCreery, et al., 2015) and more cumulative auditory experiences (Archbold et al., 2009; Cesur et al., 2020). Conversely, limited HT use is associated with the presence of additional disabilities (McCreery & Walker, 2017), limited access to healthcare services (Wiseman & Warner-Czyz, 2018), insufficient benefit perceived (Muñoz, Larsen, et al., 2019), unsupervised contexts (Walker et al., 2013), and retention challenges (Muñoz et al., 2014).

It is not surprising that higher maternal education can positively impact both the language abilities of children with hearing loss (Yoshinaga-Itano, 2003) and their HT use (Marnane & Ching, 2015; Walker et al., 2017; Wiseman & Warner-Czyz, 2018). A higher level of maternal education is a common factor associated with the vocabulary and linguistic competence of children with normal hearing (Weisleder & Fernald, 2013), expectedly also influencing HT use in children with hearing loss. Walker et al. (2013) found an almost two-hour difference in daily HA use between children of mothers with a college or high school education and those with a lower level of education (Walker et al., 2013),

describing higher HA use in children whose mothers had a higher level of education. Maternal education was also associated with higher HA and CI use in 413 Australian 3-year-old children (Marnane & Ching, 2015). These authors suggested that increased HT use in children of mothers with a higher level of education may be related to the mothers' knowledge and insight into the positive link between robust child development and consistent HT use.

The age of the child was also identified as a common factor that can influence HT use (Busch et al., 2019; Cesur et al., 2020; Easwar et al., 2016; Marnane & Ching, 2015; Walker, McCreery, et al., 2015; Wiseman & Warner-Czyz, 2018). As older children sleep less than infants (Galland et al., 2012), it is presumed that they are awake longer and have more opportunities to have auditory experiences with their HT (Park et al., 2019). There is also some evidence that a more challenging temperament or factors related to emotional states, such as child health or disposition, more pronounced in younger children, can negatively influence HT use in children (Moeller et al., 2009). In addition, adults often need to assist younger children during HT insertion, placement, and general care and maintenance (Klein et al., 2019; Peters & Anderson, 2019). In contrast, older children are more mature, often making their own decisions about when and where they will use their HT (Gustafson et al., 2015; Klein et al., 2019; Peters & Anderson, 2019). This developmental maturity may either increase HT use because older children do not require assistance from adults or decrease HT use due to social pressures experienced (Wiseman & Warner-Czyz, 2018).

Another factor that could influence HT use relating to the child's age is their history of auditory experiences with HT or the duration of HT use (Cesur et al., 2020; Easwar et al., 2016). Easwar et al. (2016) identified a longer duration of auditory experiences correlated with more consistent CI use. A different study compared canonical babbling and early consonant production in <2-year-old children using either HAs or CIs with peers with normal hearing (Löfkvist et al., 2020). While they reported that a longer duration of CI experience promoted consistent CI use, it did not achieve a similar effect in the children using HAs. Similarly, Wiseman and Warner-Cruz (2018) also observed that the duration of CI experience was not significantly associated with daily device use.

Furthermore, the degree of the child's hearing loss was established as a predictor factor that influences HT use. The more severe the degree of hearing loss, the greater the need to use technology for awareness of environmental sounds and audibility of speech. Increased HA use was associated with moderate to severe hearing loss in older children (Muñoz et al., 2014; Walker et al., 2015, 2013). Marnane and Ching (2015) investigated how the degree of bilateral hearing loss in 3-year-old children influenced their HA and CI use. They used the *Parents' Evaluation of Aural/ Oral Performance of Children* (PEACH) questionnaire (Ching & Hill, 2007) to gather parental feedback

reporting device use. Their results suggested that 87% of the paediatric CI recipients (51 bilateral, 52 bimodal, and 13 unilateral CI recipients) used their speech processors full time (defined as ≥7.5 hours a day) in comparison to 65% of the paediatric HA users (*n* = 297). The authors argued that HT use was higher in CI recipients as they had a more severe degree of hearing loss with less or no residual hearing compared to children who used HAs.

Additionally, the situational context wherein children use their HT can positively or negatively impact the usage thereof. Young toddlers demonstrated more consistent HA use in a supervised context at home because their caregivers could monitor retention (Moeller et al., 2009). Younger children using CIs are more susceptible to reduced use because of the positional challenges caused by objects such as headrests in car seats or strollers (Easwar et al., 2016). In contrast, 7- to 10-year-old children often only use their HT at school but prefer not to use it in social environments (Gustafson et al., 2017). Walker et al. (2013) agreed that specific environments could be problematic for maintaining consistent HA use, particularly for children with milder hearing losses, as they can follow some conversation without their HAs. In these contexts, caregivers may be more amenable to allow their children not to use their HT (Walker et al., 2015).

Finally, it is not surprising that households with a lower socio-economic status could be a factor associated with reduced HT use in children (Marnane & Ching, 2015; McCreery et al., 2015; Walker et al., 2015), considering the link between lower socio-economic status and poorer general health in children (Kivimäki et al., 2020). Wiseman and Warner-Czyz (2018) cautioned that low-income households could have more pressing needs such as medicine or food and fewer resources such as time and support systems than to spend their means on optimising HT use. Audiologists involved with children with hearing loss are also cognizant of the associated challenges when children fitted with HT live in economically disadvantaged circumstances. These include health literacy barriers such as lack of caregiver knowledge and awareness of the signs of childhood hearing loss (Brough & Kachaje, 2020; Bush et al., 2017; Joubert & Githinji, 2014) and the importance of early intervention (Lester et al., 2011; Merugumala et al., 2017). Financial barriers, such as the costs for transport to healthcare centres (Brough & Kachaje, 2020; Bush et al., 2014; Merugumala et al., 2017) and the out-of-pocket expenses for allied healthcare services (Hanass-Hancock et al., 2017; Scheepers et al., 2014), are also frequently reported. Wiseman and Warner-Czyz (2018) found a significant difference in the daily CI use of 71 children from Texas, United States, based on their medical insurance status. The children on government-funded healthcare exhibited fewer hours of CI use than those on private healthcare, suggesting a correlation between the lack of medical insurance and reduced CI use. Bearing in mind that HT use decreases as families' socio-economic status declines (Walker et al.

2013), the risk of poorer auditory-based outcomes for children with hearing loss burgeons when children grow up in such contexts.

Considering the multiple factors that can influence HT use as described above, it is evident that factors related to different domains, such as child, hearing, family, socio-economic, and intervention, could influence HT use in children. When promoting auditory-based communication outcomes in children with hearing loss, increased knowledge about all the relevant factors that influence HT use can improve evidence-based management strategies and approximate outcomes for children with hearing loss. In addition, exploration of predictive factors could identify extrinsic predictors that could be malleable, effectively creating enablers to professionals and families. However, there is a lack of evidence supporting hearing healthcare services supporting auditory-based outcomes in children with hearing loss, especially in resource-constrained settings like South Africa. While substantial reports from low- and middle-income countries (LMICs) are available on the burden of childhood hearing loss (Adadey et al., 2017; Orji et al., 2020; Ramsey et al., 2018; Stevens et al., 2013; World Health Organization, 2021), risk factors and aetiologies of childhood hearing loss (Adegbiji et al., 2018; Ahmed et al., 2017; Kuschke et al., 2020) and the limited otorhinolaryngology and audiological services available in LMIC settings (Bush et al., 2017; Fagan & Tarabichi, 2018; Khoza-Shangase & Kanji, 2021; Mulwafu et al., 2017; O'Donoghue et al., 2017; Peer, 2015), a general lack of evidence regarding any outcomes in children with hearing loss is noted. This paucity of evidence is even more pronounced when examining auditory-based communication outcomes in children with hearing loss from LMICs. Firstly, no evidence about HT use is currently available, except for a recent study from Turkey reporting average CI use for 4 to 8-year-old children (n = 32) of 10.5 to 12.3 hours (Cesur et al., 2020). Their results compared well with reports from high-income countries (HICs) like Canada (De Jong et al., 2021; Easwar et al., 2018), but generalisation to other LMICs settings should be considered cautiously. Turkey already implemented its national newborn hearing screening (NHS) program in 2004 (Bolat et al., 2009; Kemaloğlu et al., 2016), and access and availability to suitable HT, audiological and aural re/habilitation are well established (Bruijnzeel et al., 2017; Sevinç & Şenkal, 2021). Secondly, all current evidence of predictive factors for HT use in children originated from HICs (Busch et al., 2017; Marnane & Ching, 2015; McCreery et al., 2015; Muñoz et al., 2014; Muñoz, Larsen, et al., 2019; Park et al., 2019; Persson et al., 2020; Walker et al., 2013). Contextual research from LMICs, where more than 80% of children with hearing loss are born (World Health Organization, 2021), is required to guide paediatric hearing healthcare services in these regions appropriately (Desalew et al., 2020).

There is also limited investigation into other clinically relevant factors that could influence HT use in children with hearing loss, from either HICs or LMICs, such as the impact of multiple caregivers on HT use (Booysen et al., 2014a, 2014b), the child's ability to use HT independently (Klein et al., 2019), and regular aural re/habilitation attendance (Ekberg et al., 2020; Park et al., 2019; Wiseman & Warner-Czyz, 2018). While existing research provides insight into children with hearing loss's usage of either HAs or CIs (Gagnon et al., 2020; McCreery et al., 2015; Walker, McCreery, et al., 2015), there is a lack of evidence using similar methodologies when comparing recorded HT use of different HTs or HT fitting configurations. Identifying predictors of HT use in children from resource-constrained settings will enhance evidence-based hearing healthcare services that advocate optimal auditory-based communication in children with hearing loss. Therefore, this study investigated predictors of HT use in children and determined its prognostic significance in a diverse, unselected sample of children with hearing loss.

2. METHODOLOGY

2.1 Research Aim

This study aimed to identify and describe predictors of HT use in children with hearing loss.

2.2 Research Design

A retrospective cohort study design was employed to address the study's aim. This design allowed for clinical records of paediatric HT users to be reviewed to identify variables that could influence HT use. A retrospective study design was deemed appropriate for the current study as it allowed the analysis of a large sample of observational and clinical data (Wilkinson, 2016). Retrospective cohort studies examine recorded patient information from clinical records to answer specific research questions (Kaji et al., 2014) where the randomisation and manipulation of independent variables are not possible (Mertler, 2016). Patient clinical records are not only judged the gold standard for studies identifying predictive variables (Dillard et al., 2020; Gregory & Radovinsky, 2012), it is also considered an emerging tool in the communication sciences that can illustrate issues of considerable clinical impact (Wilkinson, 2016).

A cohort refers to a recruited subgroup of participants within a specific population sharing the same characteristics (Leedy & Ormrod, 2020). Cohort studies are also known as descriptive research since it aims to identify, describe, and interpret an observed phenomenon (Leedy & Ormrod, 2020). Descriptive research is non-experimental and is used to conduct quantitative research where variables are measured as they occur naturally (Mertler, 2016). As the purpose of quantitative research is to investigate a particular topic or activity through identifying relationships among quantifiable variables (Leedy & Ormrod, 2020; Mertler, 2016), the data collected in this retrospective record review was quantitative, pre-recorded, and patient-centred. Data logs, collected longitudinally, was used to answer the research question.

2.3 Participants

Children (<11 years of age) with hearing loss who use HT were considered participants for this study and were selected through non-probability convenience sampling. This technique allows the researcher to gather the sample from a cohort through a process that does not allow the entire population an equal opportunity to be included as participants (Etikan et al., 2016; Leedy & Ormrod, 2020). Convenience sampling emphasises generalizability, while the sample size increases the convenience sample's statistical power (Etikan et al., 2016; Gaeta & Brydges, 2020). The quantitative

nature of the research served to support the choice of a convenience sampling technique (Babbie, 2010; Etikan et al., 2016).

The study site was an auditory-oral intervention program, namely the Carel du Toit Centre in Cape Town, Western Cape. Presently, it is the only facility in South Africa that offers comprehensive care to children with hearing loss acquiring spoken language and their families (Carel du Toit Centre and Trust, 2021; Du Toit, 1975). Children diagnosed with hearing loss at various clinical settings (such as tertiary hospitals and private practices), aged between birth to 11 years of age can access one or any combination of the program's services, including family-centred early intervention, a pre-primary and foundation phase schooling program (supported by the Western Cape Department of Education), audiological management, support services such as speech-language therapy, occupational therapy and social work and two residences for short and long-term visiting families to the Centre. Most children spend multiple years in the program, accessing all or some of the support services offered (Carel du Toit Centre and Trust, 2021). Children from both public and private healthcare sectors are enrolled in the intervention program, making it mostly representative of the paediatric population with hearing loss in South Africa acquiring auditory based communication outcomes.

The following inclusion criteria were specified for participants:

- children (<11 years of age) enrolled at the Carel du Toit Centre between 2010 and 2018
- diagnosed with either a unilateral or bilateral hearing loss and including all types, degrees, and onsets of hearing loss
- fitted with digital HT (conventional HAs, CIs, and BCHDs) with data logging capabilities
- a record of at least three data logs with the same HT during a calendar year
- caregiver consent for anonymised data collection.

The clinical records of 556 children enrolled in the intervention program between 2010 and 2018 were available. Of these, six families declined consent for either prospective or retrospective data collection. Another 45 potential participants did not meet the criteria. A sample of 505 participants remained. While there were multiple years' data available for some children, the data from the coinciding calendar year with the most data logs were selected. Each child's data was only analysed once. The sample included children aged between birth to ≤12 months (*n* = 50), 13 to 24 month olds (*n* = 59), 25 to 36 month olds (*n* = 54), 3.1 to 4 year olds (*n* = 51), 4.1 to 5 year olds (*n* = 58), 5.1 to 6 year olds (*n* = 53), 6.1 to 7 year olds (*n* = 51), 7 to 8 year olds (*n* = 36), 8-9 year olds (*n* = 48), 9-10 year olds (*n* = 39) and six children between 10.1 to 11 years of age.

A sample size and statistical power calculation were completed to ascertain that a suitable sample size was available (Gearing et al., 2006). Leedy and Ormrod (2020) advised that calculating sample size is critical because it provides a basis for estimating sampling error. Power calculations are relevant because it determines whether there were sufficient participants to answer the research question. In addition, Gaeta and Brydges (2020) advised that it is an essential step in any retrospective record review when carrying out speech, language, and hearing research. Given the final sample size of 505 participants and the effect size of ($f2$) = 1.546, a high-power level (α level = 1) was achieved to detect a false null hypothesis, indicating that a large enough sample was available to answer the research question.

2.4 Ethical Considerations

When conducting research ethically, one of the fundamental principles is protecting and safeguarding the human dignity and rights of the participants involved (Chabon et al., 2011). Researchers are responsible for applying this code in an honest, accountable, and ethically justifiable manner (Babbie, 2010). The study incorporated and adhered to guidelines relevant to the South African context (Department of Health Republic of South Africa, 2015; Health Professions Council of South Africa, 2008; Mouton, 2001; University of South Africa, 2016) as well as those specified to student researchers in the guidelines of the University of Pretoria's research's code of ethics (University of Pretoria, 2018). The fundamental ethical principles of justice, autonomy, beneficence, and non-maleficence were ensured by following these guiding principles and values. Furthermore, Institutional review board clearance (HUM010/0219) was obtained from the University of Pretoria's Faculty of Humanities' Research Ethics Committee before the collection of data commenced (Appendix A). The individual ethical principles and applications employed during the study are listed and explained in Table 2.

Table 2. Ethical principles applied in the research design (Department of Health Republic of South Africa, 2015; Health Professions Council of South Africa, 2008; Mouton, 2001; University of Pretoria, 2018)**.**

Guiding principle	Application to the study
Informed consent	
The principle of informed consent required that participants have the right to be informed of the research's purpose, the potential harm, and the extent to which their confidentiality and privacy will be maintained.	As the retrospective nature of the study did not involve active participation, informed consent could not be obtained from the participants or their caregivers. However, during admission to the intervention program, caregivers provided written consent to the intervention program to release information for research (Appendix B) without renewed consent required for new projects. Caregivers provided written consent to "*access and copying rights of the child's medical, audiological and psychological records. This information may be used for the purpose of research, publications in scientific literature ... child confidentially will be maintained at all times.*" The Carel du Toit Centre principal acts as custodian of the data in the participants' files and received an information letter (Appendix C) outlining the relevant details, such as the purpose of the study. The principal completed and signed a consent letter, permitting the release of the clinical records (Appendix D).
Right to privacy and confidentiality	
Participants partaking in the research had the right to privacy and confidentiality, considering that privacy concerns participants, whereas confidentiality involves the participants' data. Privacy is concerned with who has access to the participant's personal information and records. Confidentiality refers to implementing appropriate measures to prevent information disclosure that might identify the participant either during the research or afterwards.	In retrospective research, data is separate from its source (a particular child) but still symbolises an individual. Throughout the study, participants' right to privacy was protected by handling their data with meticulous confidentiality. The researcher and the data-entry verification audiologist were the only persons who accessed the clinical records. Furthermore, a unique alpha-numerical code was assigned to each participant, only known to the researcher, ensuring confidentiality. This code was used in the electronic data capturing sheets so that any identifying information was omitted. Additionally, data was reported anonymously in the research article and the dissertation.
Storage of data	
Confidentiality also refers to implementing appropriate measures to prevent information disclosure that might identify the participant (inadvertently or not) either during the research or afterwards. In addition, the Protection of Personal Information Act, 4 of 2013, require careful gatekeeping of raw data, computer safety, and locked record storage facilities. De-identified data storage was required.	The raw data was entered, de-identified, managed and analysed on a restricted-access electronic data sheet secured on a cloud-based server during the study. After completing the study project, all data will be stored electronically at the Department of Speech-Language Pathology and Audiology, the University of Pretoria, on a password-protected computer for a minimum 15-year retention period (i.e., the year 2036). In addition, data will also be uploaded to the University of Pretoria's Research Data Repository (Figshare).

Guiding principle	Application to the study
Respect for persons (dignity and autonomy)	
A primary concern is demonstrating respect for the dignity, wellbeing, and safety of the participants.	The retrospective nature of the research ensured that there was no active participation. Therefore, participants were not exposed to additional expectations or unusual stress.
Protection from harm	
The risk-to-benefit ratio had to be favourable, meaning that the likelihood of benefit from participation in the study outweighed the risk of harm to the participants, community, and society.	The retrospective nature of this study design prevented any exposure to risks to the participants of this research project.
Fair selection of participants	
The selection, inclusion, and exclusion of participants were just, fair, and based on ethical and scientific principles.	Participants using HT from diverse demographical environments were included. There was no discrimination between participants on the grounds of any prohibited bases, such as age, economic status, marital status, religious belief, gender, disability, ethnicity, education, religion, marital status, social origin, or language.
Scientific integrity and ethical clearance	
The research design, aim, and objectives were scientific, ensuring that the research's academic integrity was above suspicion.	This study incorporated a sound design to address the research aim. The research proposal was subject to ethical approval (HUM010/0219) from the Faculty of Humanities Research Ethics Committee, University of Pretoria (Appendix A).
Plagiarism	
Researchers are obligated to their colleagues to produce original work, refraining from plagiarism.	The researcher attempted to avoid plagiarism and present her original work while acknowledging sources included (please refer to page 4 of this dissertation for the plagiarism declaration).
Release of findings	
The principle of distributive justice required that the research study distribute the benefits of knowledge derived from the research. Results will be published, regardless of the study's outcome, in a timely, competent manner.	The researcher is publishing the results in a dissertation and research article (Appendix E), which may be used by and distributed to the public. Results will also be shared with the intervention program through a presentation and report.
Professionalism, competence, and experience	
The researcher is part of a regulated profession and should exhibit professional characteristics such as answerability and integrity while upholding the quality and rigour of the research.	The researcher is experienced in Audiology and Speech Therapy due to her undergraduate qualification and 19 years of clinical experience. Additionally, the researcher engaged with two supervisors and other key role players at various research stages. The researcher (STA 0022101) and supervisors are registered with the Health Professions Council of South Africa.

2.5 Data Collection Material

The first step for this retrospective record review was to develop an electronic data collection tool for the study (Gregory & Radovinsky, 2012). The researcher piloted similar electronic data collection tools in earlier studies (Booysen et al., 2014b, 2014a; Booysen & Eksteen, 2017), which assisted in determining the feasibility of data abstraction from the clinical records of potential participants in this study (Kaji et al., 2014). Electronic data sheets are cost-effective in large investigations and allow for easier centralisation and access (Gearing et al., 2006; Juluru & Eng, 2015). However, manual entry is known to influence the validity of the data, so the format, units, and abbreviations of each value entered into the spreadsheet needed to flawless and uniform (Juluru & Eng, 2015). Subsequently, multiple strategies were built into the electronic datasheet to minimise errors, such as restricting response options (Kupzyk & Cohen, 2015) and automatically checking the syntax range entered (Juluru & Eng, 2015). Refining strategies and formatting guidelines (Gregory & Radovinsky, 2012; Juluru & Eng, 2015) were incorporated to make the datasheet logical and user-friendly. The electronic *Microsoft Office Excel* datasheet clarified, organised, and simplified the captured data.

The data collected for this study were extracted from the clinical records of the participants. Each child that enrolled at the intervention program had a comprehensive hard-copy clinical file that contained records of case history questionnaires, demographic information, speech and language assessment reports, individualised educational plan and goals, academic results, and reports from the various professionals on the multidisciplinary team. This is possible because each department at the research site, namely early intervention, audiology, occupational therapy, psychology, social work, speech-language therapy, schooling program, and general administration, creates child-specific files for the children under their care where all the documents collected and generated are retained. This profession-specific file is kept up to date within each department. Once a child graduates from the program, all these documents from separate clinical files are collated into one archived clinical folder. For example, routine capturing of audiological information included running case history notes, biannual diagnostic hearing assessments, HT verifications and validations, electroacoustic modifications to HT, and technical reports after HT service or repairs. HA verification results included aided and unaided speech audibility (speech intelligibility index), individually real ear to coupler difference measures, speech maps demonstrating HA targets and gain, generally within 5 RMS when appropriately fitted with suitable HT. The study site's standard audiological management protocol included collecting a minimum of one data logging recording per quarter with a screenshot of the HT use printed and filed in the patient file. This comprehensive recordkeeping system allowed the researcher to use the clinical records for data capturing retrospectively.

Specific data from different domains were targeted for data collection to address the study's aim: The different areas included demographic, family, intervention, socio-economic, audiology-related and HT information, including data logging records indicating HT use. Table 3 summarises each of these categories with the available data selected for data collection.

Table 3. Data collected, coded, and calculated for each participant in this study

Dependent Variable

Outcome variable - HT use

- Multiple data logging recordings for each HT used
- First and the last date of data logs captured during the calendar year

Independent Variables

Demographic information

- Gender
- Population group
- Additional diagnosed developmental conditions
- Language agreement (between home and education)
- Chronological age
- Communication mode

Family information

- Family history of HL
- Parent with HL using HT
- Maternal level of education
- Paternal level of education
- Number of languages used at home
- Number of caregivers
- Marital status
- Family participation in intervention

Intervention information

- Regularity of professional HT check
- Caregiver intervention attendance
- Caregiver responsible for intervention
- Independent HT user
- Parent comfort with HT

Socio-economic status information

- Social disability grant recipient
- Transport subsidy to intervention recipient
- Food parcel subsidy recipient
- Subsidised battery recipient
- Access to healthcare
- Travelling distance to the intervention site
- Monthly family income

Audiology-related information

- Type of HL
- Degree of HL (better ear 4FPTA)
- Bilateral or unilateral HL
- Chronic otorrhea
- Onset of HL
- Newborn hearing screening (NHS)
- Age at HL diagnosis
- Age at initial HA fitting
- Age at enrolment in intervention
- Age at (initial) CI activation
- Cumulative auditory experience with HA
- Cumulative auditory experience with CI

HT information

- Type of HT fitting or categories
  Binaural HAs
  Bilateral CIs
  Bimodal HT (CI and HA)
  Monaural HT (CI/HA) but bilateral HL
  Monaural HT and unilateral HL
  Bilateral HL and BCHD HT (BCHD and HA)
- Funding of HT
- Best practice binaural audiological management of HL
- Site of audiological management

Dependent Continuous Variable

HT use. The outcome variable was determined using the multiple data logging recordings in each child's clinical records collected during a calendar year as part of the standard audiological management protocol at the intervention program. Each of these logs had a coinciding start and end date, retrieved to determine the median chronological age during the period of HT use recorded.

Independent Categorical and Continuous Variables

Table 3 referred to the specific independent variables targeted for data collection to address the study's aim. The potential prognostic factors identified were defined as either categorical (dichotomous or polytomous) or continuous variables, depending on the available data. These independent variables will be discussed according to five different subsections: demographic, family, intervention, socio-economic, and audiology-related sections.

Demographic Information. Data collected from each clinical file included (a) gender (male or female); (b) population group; (c) additional developmental conditions; (d) language agreement; (e) chronological age; and (f) communication mode. The official population group classification terms in South Africa, Black African, Coloured, White and Indian/Asian (Statistics South Africa, 2016, 2018) were used to define race. The population groups Indian/Asian and Coloured were collapsed for statistical analysis. Additional developmental conditions were clustered as either a confirmed positive or negative diagnosis of developmental conditions such as attention deficit disorder or cerebral palsy. While the language of education and home language was recorded separately, the study used these two variables to determine the categorical variable language agreement. For this study's purpose, language agreement was defined to indicate whether the language at home and the language of education were the same or not. Median chronological age was determined during the data processing stage. For the ease of statistical analysis, chronological age, a continuous variable, was described in months throughout the study. Communication mode data were grouped into either an auditory-oral mode of communication or a bimodal communication mode.

Family Information. This subsection included the following: (a) a positive or negative family history of childhood hearing loss; (b) caregivers with a hearing loss who used HT or not; (c) maternal; and (d) paternal level of education; (e) number of languages used at home; (f) number of caregivers involved in the child's life; (g) parental marital status (married or other); and (h) family participation in intervention. Even though each caregivers' educational level information was available, it was decided to group it dichotomously as either an education level of matric or a higher

level of education versus an education level less than Grade 12. The study defined the number of caregivers involved as the number of people in a child's life taking responsibility for caring for the child, specifically relating to different home environments, such as a child who grows up in two homes. The data were bracketed into a dichotomous variable for analysis: a child with one primary home or multiple caregivers living in different homes. Family participation in intervention is a metric developed by Moeller (2000) that demarcated family participation into five categories ranging from *limited, below-average*, *average*, *above-average* to *ideal participation*. These five sub-categories were minimised into a dichotomous variable – good participation (*above-average* and *ideal*) versus limited participation (*limited*, *below-average*, and *average*).

Intervention-Related Information. This domain included (a) the regularity of a professional HT check; (b) caregiver responsible for the re/habilitation; (c) regular caregiver attendance of intervention appointments; (d) child ability to use HT independently; and (e) parent comfort with use and insertion of technology. The study defined the regularity of the professional HT check (at a minimum, a listening check with a stetoclip/microphone earphone and the *Ling* six-sound test) according to the frequency it occurred, either daily, weekly, or irregularly. The caregiver responsible for re/habilitation referred to the primary person who took responsibility for attending intervention appointments and communicating with the child's intervention team. This variable was bracketed to indicate the responsible person as either a parent or a non-parent, such as a grandparent. A metric of appointment attendance was calculated as the number of intervention sessions attended divided by the number of scheduled intervention appointments. This percentage score was then clustered into a dichotomous categorical variable. The sub-category regular caregiver intervention attendance was defined as a ≥75% attendance score, whereas the sub-category irregular adherence to intervention attendance referenced caregiver intervention attendance records of <75%. This criterion was based on earlier literature demonstrating that a minimum of ≥70% attendance to a treatment program (such as physiotherapy following a stroke or intervention for children with autism) was defined as *adherence to treatment* (Bennett et al., 2020; Carr et al., 2016; Carr & Lord, 2016; Lever et al., 2019; Ntamo et al., 2013). Data on the child's ability to independently use HT was bracketed as independent, referring to no adult assistance required versus dependent, referring to requiring any level of assistance with tasks such as insertion. Caregiver comfort with HT was based on the same two categories.

Socio-Economic Information. This dimension included (a) whether the child received a care dependency grant (social disability grant); (b) subsidised transport; (c) subsidised food parcels; and (d) subsidised disposable HT batteries. It further included (e) the child's type of access to healthcare

services; (f) one-way travelling distance to the intervention program; and (g) monthly family income. In South Africa, the government employs social assistance to improve living standards in society and is given to people who are vulnerable and require state support (South African Government, n.d.). At the time of data collection, the care dependency (disability) grant assisted full-time caregivers of children with disabilities with an R1780 ($110) stipend per child per month (Hanass-Hancock et al., 2017). Medical doctors bestowed the care dependency grant to children with bilateral severe to profound sensory-neural hearing loss (SNHL) if the family could provide proof that they earned less than R20000 ($1350) a month. Children with milder degrees of hearing losses or unilateral hearing losses do not qualify for this grant, nor do older children who can already communicate using spoken language (Davids et al., 2021; South African Government, n.d.; Störbeck & Young, 2016). The study bracketed the need for a transport subsidy into a dichotomous affirmation of a yes or no, considering that the monthly transport cost to the pre-primary school of the intervention program ranged between R650 to R1800 ($58-$123) a month per child. This also included covering 50% of a caregiver's public transport fare for weekly intervention attendance. This same metric (yes or no) was applied to the weekly subsidy of a food parcel and batteries. Every week, families can purchase a shopping bag filled with R150 - R200's ($10 to $14) worth of unperishable goods for the cost of R10 (<$1), as sponsored by the intervention program. Families can receive six new battery cells in return for six depleted battery cells when visiting a primary healthcare clinic (subsidised by the Department of Health). Type of healthcare was grouped as public healthcare or private healthcare with a third category, combined, added. This was considered necessary due to the large number of children who had private medical insurance for hospitalisations but no benefit for allied health services or HT, requiring assistance from public health care for diagnostic assessments, HT, and intervention. One way travelling distance to the intervention program was bracketed into three categories, indicating <10 km, 10-50 km, or >50 km travelling distance. Family income was collapsed into one of the following three parameters, <R2999 (<$208), R3000 to R9999 ($200 to $700), and >R10000 (>$700) family income per month.

Audiology-Related Information. This domain included (a) the type of hearing loss; (b) the degree of hearing loss; (c) the laterality of hearing loss (unilateral or bilateral); (d) the presence or absence of chronic otorrhea; (e) the onset of the hearing loss; and (f) if the child had NHS or not. Furthermore, this category incorporated the categorical variables (g) the type of HT; (h) funding of HT; (i) best-practice audiological management; and (j) the site of audiological management. Also included were the continuous variables (k) child's age at diagnosis; (l) age at initial HA fitting; (m) age at enrolment in intervention; (n) age at initial CI activation; (o) cumulative auditory experience with HAs; and (p) cumulative auditory experience with CIs. The study minimised SNHL and auditory

neuropathy (ANSD) into one category, with conductive hearing loss (CHL) and mixed hearing loss (MHL) grouped into the other dichotomous category. For this study, the WHO classification system for degree of hearing loss (Emmett et al., 2016; Humes, 2019; Olusanya et al., 2019; World Health Organization, n.d.), based on a four-frequency pure tone average (4FPTA) of 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz in the better ear, was used to classify the degree of hearing loss. Five categories were available, namely normal hearing (≤26 dB HL), mild (26-40 dB HL), moderate (31-60 dB HL), severe (61-80 dB HL), or profound hearing loss (≥80 dB HL). While this classification system differs slightly from the well-recognised ASHA classification system (Clark, 1981), it aligns with the WHO recommendation to use a standardised method of classifying degrees of hearing loss. It is pertinent in LMICs, where information regarding childhood hearing loss is still scarce (Khoza-Shangase & Kanji, 2021). The onset of hearing loss was clustered in a dichotomous categorical variable, with congenital or early-onset hearing losses bracketed together and progressive or acquired hearing losses as the opposing category. The terms congenital and early-onset hearing loss generally indicate a hearing loss present at birth or diagnosed within the first three months of life, with late-onset hearing loss used to indicate the occurrence of hearing loss after a passed hearing screen or confirmation of normal hearing through audiological assessment, typically after three months of age (Joint Committee on Infant Hearing, 2019; Vos et al., 2019). When applying these definitions in a context where NHS is not standard practice, it is challenging, if not impossible, to differentiate between congenital and late-onset childhood hearing loss. Subsequently, considering the South African context, for the purpose of this study, hearing loss was coded as congenital or early-onset if sufficient evidence was available to suggest that the hearing loss was present before 12 months of age and considered delayed onset (progressive or acquired) if sufficient evidence suggested a change in hearing after 12 months of age.

For statistical analysis, HT fitting was ultimately clustered into six categories: Binaural HAs (bilateral hearing loss), bilateral CIs (bilateral hearing loss), bimodal (CI and HA- bilateral hearing loss), unilateral HT (HA, CI, or BCHD – but a bilateral hearing loss), unilateral hearing loss (unilateral hearing loss using either a HA or BCHD) and other (bilateral hearing loss using two BCHDs or a BCHD and HA combination). The data collected categorised ear-specific HT funding into multiple categories (self, medical aid, government, donated, loaner devices) and subsequently collapsed it into self-payment or subsidised HT. Ear specific funding was originally collected considering the large number of children with binaural HT funded independently of each other. As only the ear with the highest data logging's use was ultimately utilised in this study, the study associated the ear specific technology's funding with the ear with the highest data logging during the data cleaning phase. The variable best practice binaural audiological management was included because optimal auditory

access to sound facilitates auditory-based communication outcomes (Flexer & Wolfe, 2020; Klein et al., 2019; Walker et al., 2017) is not a given in South Africa. The audiology department at the study site completed ear-specific HA fittings, according to international guidelines and protocols (American Academy of Audiology, 2013; Bagatto, 2016; Bagatto et al., 2016; McCreery, 2013; McCreery et al., 2013; Stiles et al., 2012), allowing the researcher to determine whether each child gained ear-specific optimal auditory access. Subsequently, for the purpose of this study, best practice binaural audiological management defined whether the child was binaurally optimally aided and received optimal auditory access with a type of device appropriate for the type and degrees of hearing loss, such as bilateral bone conduction hearing devices for children with bilateral atresia (American Academy of Audiology, 2013; Bagatto et al., 2019; Gordey & Bagatto, 2020; Health Professions Council of South Africa, 2018; Leigh et al., 2016; Simon et al., 2018). The site of audiological management referred to whether the child received coordinated audiological care at the same location where they received intervention or whether it occurred elsewhere, such as a private practice or a tertiary hospital. For the ease of statistical analysis, all these variables related to age or duration of use remained continuous variables and were recorded and analysed in months throughout the study. The term cumulative auditory experience was coined to describe the culmination of audibility, HA use, and early intervention or input over time (McCreery & Walker, 2017; Walker, McCreery, et al., 2015). This study used this term to similarly define the listening experience over time (including intervention and proof of audibility) since the fitting of HT.

To summarise, many potential independent variables from various domains, including demographics, family, intervention, socio-economic, and audiology-related and HT information, were collected from the children's clinical records. An electronic datasheet template was developed for data collection because of the sample size and amount of data per participant.

2.6 Data Collection Procedures

Gregory and Radovinsky (2012) recommended that a strategic approach to data collection would determine a retrospective chart review's success. The researcher attempted to prevent investigator bias by avoiding conflicts of interest (Kaji et al., 2014), applied for institutional ethical board approval (Appendix A), and had experience in data collection and capturing at the study site (Booysen et al., 2014b, 2014a; Booysen & Eksteen, 2017). In addition, the researcher attempted to employ a sound strategy before and during data collection so that the data's reliability, the outcome, and the significance of the research were enhanced (Mann, 2003).

The first step of data collection was obtaining informed consent to access the clinical records of children with hearing loss at the study site, namely the Carel du Toit Centre. The centre's principal

was approached as she acted as the custodian of the data in all the children's clinical records. An information letter (Appendix C) with an invitation to request clarification and discussion of the research project was used for this purpose. Subsequently, the principal provided signed consent (Appendix D), permitting the researcher access to the clinical records with the already available demographical, clinical, and outcomes data required for this research project.

Secondly, the data collection tool, namely the electronic data sheet template, was developed. This included developing a comprehensive key describing all the independent variables and an indication of collapsed categories required for later data cleaning and statistical analysis.

Thirdly, the researcher extracted clinical records from the intervention program's file repository. Files were only removed if the caregivers' signed consent to release information to the intervention program was available in the respective children's records. This document indicated that the caregivers provided written consent during admission to the auditory-oral intervention program that their child's de-identified data could be used for research (Appendix B). Ten files were removed from the secure room at a time and examined to allow data entry into the electronic datasheet.

Fourthly data capturing commenced. The researcher, directly involved with the participants due to her position as one of the clinical audiologists at the auditory-oral intervention program, was solely responsible for the coding and capturing of the retrospective data from the clinical records on the electronic datasheet for the purpose of this study. All data of participants who met the inclusion criteria were manually coded and entered anonymously, using a unique alpha-numerical code. The researcher prevented data capturing errors on the electronic datasheet by applying multiple safety-net procedures. One person captured the data on an electronic datasheet with drop-down categories, decreasing coding errors and ruling out inter-rater reliabilities (Vassar & Holzmann, 2013). Additionally, as the electronic datasheet was so large that manual inspection alone would be difficult to accomplish, the application of the *Microsoft Office Excel* tools such as *freeze panes*, *filter*, *find*/*replace,* and *hide*/*unhide* offered a way to ensure data consistency throughout.

Fifthly, data entries were verified. Quality monitoring of data entries was applied after every 10 entries in the electronic data sheet to identify any inconsistencies (Gregory & Radovinsky, 2012). Validation of data entry was completed randomly sampling 10% of the files and re-entering the data, applying a double-entry technique (Barchard & Pace, 2011) at the end of data collection. Furthermore, another audiologist, blind to the study's objective but co-audiological manager of the study site, randomly verified an extra 10% of data entries to cross-check high-quality data capturing

and to ensure that the data's accuracy, quality, and objectivity were not compromised (Leedy & Ormrod, 2020). Retrospective data was captured over seven months.

Lastly, the data was cleaned and prepared for analysis by conforming it to the formatting guidelines required for the statistical analysis package. The likelihood that errors will occur and be overlooked is higher when working with large data sets (Juluru & Eng, 2015). Therefore, all the data cleaning was done in *Microsoft Office Excel* using several key functions and formulas to enable an error-free spreadsheet. One of the steps taken during the data cleaning phase was collapsing some of the data into dichotomous variables rather than polytomous variables, such as the number of caregivers where a binary cut-off was created indicating one or more than one caregiver.

2.7 Data Processing and Analysis

The first step of data processing of this study was to calculate the outcome variable, that is, average HT use. HT fitting software automatically averages HT use (data logging) between the previous and current date whenever the HT is coupled to the HT programming software. Ear specific average HT use was calculated by adding the values of multiple data logs recorded through a year and dividing it by the number of recordings available. Concurrently, each child's age was calculated as the median between the age at the dates of the first and last data logs recorded during the calendar year. Thereafter hearing hours percentage (HHP) was calculated (Gagnon et al., 2020; Park et al., 2019). The HHP equates the amount of time the child heard with their HT to the amount of time an age-matched peer would be awake and have access to sound. Accordingly, the median *awake* or *hearing hours* for a 4- to a 12-month-old child is 10 hours a day (12–16-hour sleep range), increasing to 11.5 hours (11–14-hour sleep range) for a 1- to a 3-year-old child, 12 hours (10-13-hour sleep range) for a 3- to a 5-year-old child and 13.5 hours (9-12-hour sleep range) for a 6-to 11-year-old child. Hearing hour percentage (HHP) was calculated through the following equation: *HHP = average daily HT use/total awake time per age) **. As both ears' HT use values were similar, this study followed the same process as Marnane and Ching (2015) to select the ear with the highest data logging for statistical analyses.

The descriptive and inferential statistics were calculated using the commercially available statistical software package, SAS version 9.4. Descriptive statistics (means, standard deviations, and frequencies) were used to summarise the study participants (N = 505) in terms of 42 clinical characteristics. Six types of HT fitting sub-categories were created. However, to strengthen the statistical analysis, the 11 children included in the "bilateral hearing loss with BCHD HT" category (seven bilateral BCHD users and four bimodal HA and BCHD users) were excluded for inferential statistical procedures.

Subsequently, given the number of categorical and continuous variables included in the study, bivariate analyses were completed to determine the variables associated with the outcome variable and required to build the GLM model. Analysis of variance (ANOVA; α level = 0.01) was used to determine if there was a bivariate relationship between the outcome variable, average HT use, and the 35 independent, categorical variables. Simultaneously, Pearson's correlations (CORR procedure) were used to evaluate the degree of association between the seven continuous variables and the outcome variable, namely HT use. The bivariate analyses (ANOVA and CORR) significantly associated 31 of the 42 potential prognostic factors with HT use.

Finally, regression analyses were completed. Two general linear models (GLMs) were created to examine the categorical and continuous independent variables' influence on the continuous dependent variable. In the first GLM, all 31 significant predictor variables ($p < .01$) identified through both the ANOVA and the CORR analyses were entered into the model. Following this, the final GLM was built to generate predictive factors that simultaneously had the most significant effect on HT use. This final GLM model included all variables and was derived through a manual, step-by-step procedure. The model was run multiple times, systematically removing the non-significant variables with the highest *p*-value until the model was left with the only significant predictor. Throughout the entire regression analyses, a more conservative *p*-value was utilised to indicate statistical significance ($p < .01$), owing to the relatively large sample size and specificity of the research question. This *p*-value increased the accuracy of any significant results obtained while concurrently reducing the chance of any false positives. In addition, four-way, three-way, and two-way interaction effects were performed on the final GLM to investigate the combined or interactive influence of the categorical variables on the dependent variable, HT use.

2.8 Validity and Reliability

Drawing meaningful conclusions from a research study relies on the researcher's ability to gain credible and reliable data (Leedy & Ormrod, 2020; Nelson, 2017). The validity and reliability of the study were prioritised as follows:

The Validity of the Study

Thompson and Panacek (2007) explained that internal validity refers to how rigorously a study is designed and executed. In contrast, external validity refers to whether the study's findings can be generalised to other populations (C. B. Thompson & Panacek, 2007). Panacek (2007) warned against the potential for validity errors when reviewing retrospective records, such as clinical files. By understanding these possible pitfalls, the researcher attempted to uphold validity (also called

transferability) in the research design and planning phases (Leedy & Ormrod, 2020). The researcher applied the recommended strategies below to enhance the overall quality, reproducibility, and validity of data collected from the clinical records (Barchard & Pace, 2011; Juluru & Eng, 2015; Panacek, 2007; Vassar & Holzmann, 2013).

- Previous investigations were carried out by the researcher at the auditory-oral intervention program. These investigations (Booysen et al., 2014a, 2014b; Booysen & Eksteen, 2017) were also retrospective chart reviews, using similar participants and providing the researcher with insight into the institution's record retrieval procedures, data available in the clinical records, and the feasibility of data abstraction from the records. The researcher considered these pilot phases that increased the current study's validity (Vassar & Holzmann, 2013).

- An electronic datasheet was used to ensure accuracy, consistency, and reliability while reducing data collection errors (Juluru & Eng, 2015; Vassar & Holzmann, 2013). Gearing et al. (2006) recommended that a retrospective study's internal validity and reproducibility are enhanced when data was consistent. Standardization is vital to ensuring that the study data is of sound quality, as research conclusions can only be reliably drawn if done on accurate data (Dillard et al., 2020; Gearing et al., 2006).

The Reliability of the Study

Leedy and Ormrod (2020) defined reliability as the extent to which a measuring instrument yields a specific and consistent result about the characteristics being assessed when the measured entity has not changed. Reliability is thus synonymous with stability or consistency. The researcher enhanced the reliability of the study in the following ways:

- The research's reliability was maintained because of the type of research design, namely a retrospective cohort design. There was a lack of bias as the current study's outcome was not the original reason for collecting data (Mann, 2003).

- Data logging recordings are not dependent on the child's cooperation, responses, or recall. Readings are robust against response biases and reactive behaviour, thus ideal for controlled observations (Busch et al., 2017). The use of an objective recording or measurement, such as data logging, rather than a subjective personal report, improved the data and outcome variable's accuracy. This is important because evidence suggested that parents overestimate HT use by up to 3.6 hours a day (Meibos et al., 2016; Muñoz et al., 2013, 2014; Walker et al., 2013).

- The use of an objective method like recorded data logs likely also provided similarly consistent data for children of all ages (Easwar et al., 2016). Additionally, the time resolution obtainable from studies using parental reports is often either qualitative, for example, *most of the time* (Moeller et al., 2009), or categorical, for example, *never* or *1-4 hours a day* (Marnane & Ching, 2015). An objective method improved sensitivity to minor differences and provided better resolution (in the order of hours and minutes) or precision in data obtained (Busch et al., 2017).

- Multiple data logs collected over a calendar year were averaged to increase the outcome variable's accuracy (HT use). The repeated measurement of the dependent outcome variable can help control the effect of faulty measures (Leedy & Ormrod, 2020; C. B. Thompson & Panacek, 2007).

- The researcher coded the data into the electronic data sheet for consistency. Quality monitoring of data entries was applied after every 10 entries in the electronic data sheet (Gregory & Radovinsky, 2012). Additionally, another audiologist, co-clinical manager of the participant sample, and blind to the study's objective, verified the data entries so that the data's accuracy, quality, and objectivity were not compromised (Leedy & Ormrod, 2020).

3. PREDICTORS OF HEARING TECHNOLOGY USE IN CHILDREN

Authors: Surida Booysen, Talita le Roux, Andries Masenge, De Wet Swanepoel

Journal: International Journal of Audiology

Submitted: 18 December 2020

Accepted: 2 April 2021

DOI: https://doi.org/10.1080/14992027.2021.1913521

3.1 Abstract

Objective: To identify and describe predictors of daily HT use in children.

Design: Retrospective review of clinical records. Multiple regression analyses were performed to identify predictors.

Study Sample: The sample included 505 children (<11 years of age) using hearing aids (HAs), cochlear implants (CIs), and bone conduction hearing devices (BCHDs).

Results: Average HT use was 9.4 hours a day. Bivariate analyses yielded 31 potential predictors from the 42 variables included. The general linear model (p <.01, R^2= 0.605) identified 10 interacting factors that significantly associated with increased HT use. Intrinsic predictors of increased HT use included older chronological age, more severe degrees of hearing loss, and older ages at diagnosis and initial HA fitting. Extrinsic predictors included the child's ability to independently use HT, at least one CI as part of the HT fitting, coordinated onsite audiological management, self-procured batteries, auditory-oral communication mode, and regular caregiver intervention attendance.

Conclusions: Average HT use was high, approximating hearing hours of peers with normal hearing. CI recipients demonstrated higher HT use compared to children using other HT. The newly identified factors can predict and increase HT use in children while contributing to evidence-based intervention services that promote optimal auditory-based outcomes.

Keywords: hearing technology use; hearing aids; cochlear implants; bone conduction hearing devices, children; data logging; predictors; childhood hearing loss, retrospective cohort study, general linear model

3.2 Introduction

Children with hearing loss have the same potential to acquire auditory-based communication as their peers with normal hearing (Flexer & Wolfe, 2020). Since access to the acoustic speech spectrum is a prerequisite for auditory-based communication outcomes (McCreery & Walker, 2017), the "eyes open, ears on" use of hearing technology (HT) is recommended following the diagnosis of childhood hearing loss (American Academy of Audiology, 2013; Flexer & Wolfe, 2020, p. 52). While

there is little direct evidence about what quantity of HT use is required in children with hearing loss (McCreery & Walker, 2017), it is reasonable to argue that HT use should approximate the hearing hours of peers with normal hearing to achieve similar spoken language and literacy outcomes. Consistent use of well-fitted HAs in children with hearing loss is associated with better vocabulary, grammar (Walker, Holte, et al., 2015), speech and oral language outcomes (Tomblin, Harrison, et al., 2015), whereas increased CI use is associated with improved receptive vocabulary, language and speech recognition in paediatric CI users (Cesur et al., 2020; Gagnon et al., 2020; Park et al., 2019).

The recommendation and fitting of HT, however, do not necessarily guarantee full-time HT use. McCreery and Walker (2017) cautioned that all-day HT use is neither an achievable nor reasonable goal for families. Evidence suggests that, on average, HA use in children ranges between 5-8 hours a day (Jones & Launer, 2010; Muñoz et al., 2014; Walker, McCreery, et al., 2015). CI use ranges between 8-10 hours a day (Busch et al., 2017; De Jong et al., 2021; Wiseman & Warner-Czyz, 2018); a recent investigation found that it took 3-year-old paediatric CI recipients 17 months to reach full-time use, defined as 80% (Park et al., 2019). There is no available data on the average use of bone conduction hearing devices (BCHD) in children. Consequently, children who use HT are not exposed to the same auditory experiences, both in quantity and quality, as their hearing peers (Flexer & Wolfe, 2020). When the goal is achieving equivalent auditory-based outcomes, a better understanding of the factors that influence HT use is required (Easwar et al., 2016; McCreery et al., 2015; Walker, McCreery, et al., 2015; Wiseman & Warner-Czyz, 2018).

Several factors have previously been identified that increased consistent HT use in children, including higher maternal education (Marnane & Ching, 2015), older chronological age (McCreery et al., 2015), younger age at implantation (Easwar et al., 2016), more severe degrees of hearing loss (Marnane & Ching, 2015; Walker, McCreery, et al., 2015) and more cumulative auditory experiences (Archbold et al., 2009; Cesur et al., 2020). Conversely, limited HT use is associated with the presence of additional disabilities (McCreery & Walker, 2017), limited access to healthcare services (Wiseman & Warner-Czyz, 2018), lack of perceived benefit (Muñoz, Larsen, et al., 2019), unsupervised contexts (Walker et al., 2013), and retention challenges (Muñoz et al., 2014).

While existing research provides insight into the usage of either HAs or CIs (Gagnon et al., 2020; McCreery et al., 2015; Walker, McCreery, et al., 2015), there is a lack of evidence comparing the objective use of different HTs or HT fitting configurations in the same study. Additionally, most evidence to date of predictive factors for HT use in children originated from high-income countries (Easwar et al., 2016; Marnane & Ching, 2015; McCreery et al., 2015; Park et al., 2019; Walker et al., 2013). Contextual research from low and middle-income countries (LMICs), where more than 90% of

infants with hearing loss are born (Davis & Hoffman, 2019), is needed to guide hearing healthcare services in these regions appropriately. There is also limited investigation into other clinically relevant predictors that could influence HT use in children with hearing loss, such as the impact of multiple caregivers on HT use and the effect of aural re/habilitation (Wiseman & Warner-Czyz, 2018).

Identifying predictors of various types of HT on the HT use in children from underserved settings will contribute to evidence-based hearing healthcare services that promote optimal auditory-based outcomes. Therefore, this study investigated potential predictors of HT use and determined the prognostic significance of these factors in a diverse, unselected sample of children with hearing loss.

3.3 Methodology

This retrospective study reviewed clinical records from a database of paediatric HT users to identify variables that could influence the use of HT. The study site was an auditory-oral intervention program, namely the Carel du Toit Centre in Cape Town, South Africa. This program offers a combination of family-centred early intervention services and specialized oral schooling to children with hearing loss between birth and 11 years of age from both public and private healthcare sectors. Institutional review board clearance (HUM010/0219) was obtained before data collection commenced.

Participant Inclusion Criteria

The following inclusion criteria were specified for participants:

- children (<11 years of age) enrolled at the Carel du Toit Centre between 2010 and 2018
- diagnosed with either a unilateral or bilateral hearing loss and including all types, degrees, and onsets of hearing loss
- fitted with digital HT (conventional HAs, CIs, and BCHDs) with data logging capabilities
- a record of at least three data logs with the same HT during a calendar year
- caregiver consent for anonymized data collection.

Data Collection

An electronic database was developed to capture retrospective data from the available clinical records of 556 children enrolled in the intervention program between 2010 and 2018. Of these, six families declined consent for either prospective or retrospective data collection. Another 45 potential participants did not meet the criteria. The final study sample included 505 paediatric HT users. Possible prognostic factors were identified from the retrospective data set and defined as

either categorical (dichotomous or polytomous) or continuous variables. For the purpose of this study, the degree of hearing loss was determined using the WHO classification system (World Health Organization, 1991, 2016, 2020). Accordingly, a better ear 4FPTA of <26 dB HL was considered normal hearing, whereas 26-30 dB HL was determined as mild, 30-60 dB HL as moderate, 61-80 dB HL as severe, and >80 dB HL as a profound degree of hearing loss. The characteristics of the sample population are summarized in Table 4 according to categorical and continuous variables.

Table 4. Summary of the sample population characteristics according to categorical and continuous variables (*N* = 505).

Categorical Variables	% (*n*)		% (*n*)
Demographic and Related Factors		**Family Factors**	
Gender		Parent with HL using HT	
Male	53.1 (268)	Yes	7.2 (36)
Female	46.9 (237)	No	92.9 (469)
Population group [a]		Maternal level of education	
Black African	23.6 (119)	Primary/ high school	35.1 (176)
Coloured	49.9 (252)	Matriculated	26.8 (135)
White	26.5 (134)	Post-matric	38.1 (191)
Additional diagnosed developmental condition(s)		Family participation in intervention [b]	
Yes	33.5 (169)	Average and below (1 - 3/5)	60.0 (303)
No	66.5 (336)	Above average (4 or 5/5)	40.0 (202)
Communication mode			
Auditory-oral	86.9 (439)		
Bimodal (visual and auditory)	13.1 (66)	**Audiologic Factors**	
Language agreement (home and education)		Type of hearing loss	
Equivalent	67.5 (341)	SNHL/ ANSD	83.6 (422)
Different	32.5 (164)	MHL /CHL	16.4 (83)
		Degree of HL based on better ear 4FPTA [c]	
Intervention Factors		Normal (<26 dB HL)	1.9 (9)
The regularity of professional HT check		Mild (26-30 dB HL)	1.1 (6)
Weekly	36.6 (185)	Moderate (31 – 60 dB HL)	22.9 (114)
Daily	50.1 (253)	Severe (61 – 80 dB HL)	23.9 (121)
Irregular	13.3 (67)	Profound (>80 dB HL)	50.2 (253)
Caregiver responsible for intervention		Chronic otorrhea	
Parent	62.8 (317)	Yes	15.3 (77)
Other	37.2 (188)	No	84.7 (428)
Caregiver intervention attendance		The known onset of HL	
Poorly/ sometimes (<75%)	44.9 (227)	Congenital/early-onset	83.8 (423)
Mostly/always (≥75%)	55.1 (278)	Progressive/acquired	16.2 (82)
Independent HT user		Newborn hearing screening	
No, low, some assistance required	64.3 (325)	Yes	32.9 (166)
Independent	35.7 (180)	No	67.1 (339)
		Audiological management	
Socio-Economic Factors		Coordinated onsite	67.5 (341)
Social disability grant recipient ($108 a month)		Offsite premise (private /public health)	32.5 (164)
Yes	53.5 (270)		
No	46.5 (235)	**Type of Hearing Technology Fittings**	
Free batteries required		Binaural HAs	56.0 (283)
Required	36.8 (186)	Bilateral CIs	14.5 (73)
Non-essential	63.2 (319)	Bilateral HL and bimodal HT (CI and HA)	13.5 (68)
Travelling distance to the intervention site		Bilateral HL but monaural HT (CI/HA)	8.5 (43)
<10 km	8.3 (42)	Unilateral HL and monaural HT (HA/BCHD)	5.4 (27)
10-50 km	77.0 (389)	Bilateral HL with BCHD HT (BCHD and HA) [d]	2.1 (11)
>50 km	14.7 (74)		

Continuous Variables	*n*	Mean (age in months)	*SD* (range)
Chronological age	505	62.5	34.4 (3 – 133)
Age at HL diagnosis	505	29.9	22.0 (0 – 104)
Age at initial HA fitting	505	33.5	22.4 (1 – 105)
Age at CI activation	155	38.9	25.9 (4 – 122)
Age at enrolment in intervention	505	34.8	22.7 (2 – 105)
Cumulative auditory experience with HA	505	24.0	29.4 (0 – 115)
Cumulative auditory experience with CI	155	20.5	28.5 (0 – 106)

[a] *The South African population identifies as Black African, Coloured, Indian/Asian, or White* (Statistics South Africa, 2016, 2018).
[b] *Family Participation in Intervention scale (Moeller, 2000).*
[c] *WHO classification of the degree of HL based on the better ear 4FPTA* (World Health Organization, 1991, 2016, 2020).
[d] *Not included in the ANOVA and CORR procedures*

Data Analysis

The first step of data analysis was to calculate average HT use. HT fitting software automatically averages HT use between the previous and current date every time the HT is coupled to the programming software. Ear specific average HT use was calculated by adding multiple data logs recorded through a calendar year and dividing it by the number of recordings available. Concurrently, each child's age was calculated as the median between the age at first and last data logs recorded. Thereafter HHP (Gagnon et al., 2020; Park et al., 2019) was calculated. The HHP equates the amount of time the child had access to sound with their HT to the amount of time a typically developing child would be awake and have access to sound, as recommended in the Consensus Statement of the AASM (Paruthi et al., 2016). Accordingly, the median *awake* or *hearing hours* for a 4- to a 12-month-old child is 10 hours a day (12–16-hour sleep range), increasing to 11.5 hours (11–14-hour sleep range) for a 1- to a 3-year-old child, 12 hours (10-13- hour sleep range) for a 3- to a 5-year-old child and 13.5 hours (9-12- hour sleep range) for a 6-to 11-year-old child. Hearing hour percentage (HHP) was calculated through the following equation: *HHP = average daily HT use/total awake time per age) * 100.* (see Paruthi et al. 2016 for more about average hours awake per age). As both ears' HT use values were similar, this study followed the same process as Marnane and Ching (2015) to select the ear with the highest data logging for statistical analyses.

Descriptive and inferential statistics were calculated using the commercially available statistical software package, SAS version 9.4. Descriptive statistics (means, standard deviations, and frequencies) were utilized to summarize the study population (N = 505) in terms of 42 clinical characteristics. Six types of HT fitting subcategories were created (Table 4*, N* = 505). However, to strengthen the statistical analysis, the 11 children included in the "bilateral hearing loss with BCHD HT" category (seven bilateral BCHDs and four bimodal HA and BCHD users) were excluded for inferential statistical procedures.

Subsequently, given the number of categorical and continuous variables included in the study, bivariate analyses were completed to determine the variables associated with the outcome variable and necessary to build the GLM model. Analyses of variance (ANOVA; α level = 0.01) were used to determine if there was a bivariate relationship between the outcome variable, average HT use, and the 35 independent (categorical) variables (Table 5). Simultaneously, Pearson's correlations (CORR procedure) were used to evaluate the degree of association between the seven continuous variables and the outcome variable, namely HT use (Table 6). The bivariate analyses (ANOVA and CORR) significantly associated 31 of the 42 potential prognostic factors with children's HT use.

Table 5. ANOVA analysis results (*n* = 494).

Categorical Factors	*df*	*F* Value	Pr > *F*	*p* < .01
Demographic and related factors				
Additional diagnosed developmental condition(s)	1	17.61	< .0001	*
Communication mode	1	75.51	< .0001	*
Language agreement between home and education	1	12.12	0.001	*
Population group	2	7.08	0.001	*
Gender	1	0.23	0.628	
Family factors				
Number of caregivers involved in child's life	1	247.27	< .0001	*
Family participation in intervention [d]	1	43.67	< .0001	*
Maternal level of education	2	18.65	< .0001	*
Paternal level of education	2	17.19	< .0001	*
Marital status of caregivers	1	12.80	0.0004	*
Parent with HL using HT	1	6.44	0.012	
Number of languages used at home	1	1.83	0.177	
Family history of childhood HL	1	0.91	0.341	
Intervention factors				
The regularity of professional HT check [c]	2	10.12	< .0001	*
Caregiver responsible for intervention	1	46.59	< .0001	*
Caregiver intervention appointment attendance	1	318.08	< .0001	*
Independent HT user requiring no adult assistance	1	584.76	< .0001	*
Caregiver comfort using HT	1	304.51	< .0001	*
Socio-economic factors				
Type of access to healthcare	2	14.57	< .0001	*
Transport subsidy to intervention recipient [e]	1	36.18	< .0001	*
Food parcel subsidy recipient [f]	1	71.85	<.0001	*
Subsidized battery recipient [g]	1	114.55	<.0001	*
Monthly family income	2	57.01	<.0001	*
Social disability grant recipient ($108 a month)	1	12.12	0.0005	*
Travelling distance to the intervention site	2	2.13	0.1195	
Audiologic and HT factors				
Type of HT fitting	4	24.84	< .0001	*
Site of audiological management	1	54.35	< .0001	*
Degree of HL (4FPTA in better ear) [a]	4	13.49	< .0001	*
Type of HL	1	22.86	< .0001	*
Best-practice binaural management of HL [b]	1	17.94	< .0001	*
Chronic otorrhea	1	22.10	< .0001	*
Bilateral or unilateral HL	1	13.01	0.0003	*
Newborn hearing screening	1	4.19	0.041	
Funding of HT	1	2.19	0.140	
Onset of HL	1	1.37	0.242	

[a] *Determined using the WHO classification of hearing loss* (World Health Organization, 2020).

[b] *Best-practice binaural audiological management of HL refers to both ears fitted with the indicated HT for the degree and type of HL. For example, behind-the-ear HAs are contraindicated for children with a mixed HL due to chronic otorrhea.* (American Academy of Audiology, 2013; Bagatto et al., 2016; Fitzpatrick, Cologrosso, et al., 2019; Joint Committee on Infant Hearing, 2019).

[c] *Irregularly/ weekly/ daily.*

[d] *Classified according to the family participation scale (Moeller, 2000).*

[e] *Subsidized travelling costs provided by the intervention program to a caregiver (weekly) and child (daily) to access the intervention site.*

[f] *Families can purchase a non-perishable food parcel (average value $10-$14) weekly for <$1 from the intervention site.*

[g] *Families unable to procure readily available battery stock for use at home and school, regardless of the reason (e.g., finances, poor planning).*

df: degrees of freedom

Pr > F: p-value of the F test (with F-test testing the significance of the mode)

Table 6. CORR Procedure Results (*n* = 494).

Continuous Variables	*n*	Pearson Correlation Coefficients	Pr > *F* Prob > |r| under H0: Rho=0	*p* < .01
Chronological age	494	0.515	< .0001	*
Cumulative auditory experience with HA	494	0.519	< .0001	*
Cumulative auditory experience with CI	155	0.434	< .0001	*
Age at CI activation	155	0.354	< .0001	*
Age at HL diagnosis	494	0.106	0.017	
Age at intervention	494	0.085	0.056	
Age at initial HA fitting	494	0.081	0.070	

Pr > F: p-value of the F test (with F-test testing the significance of the model).

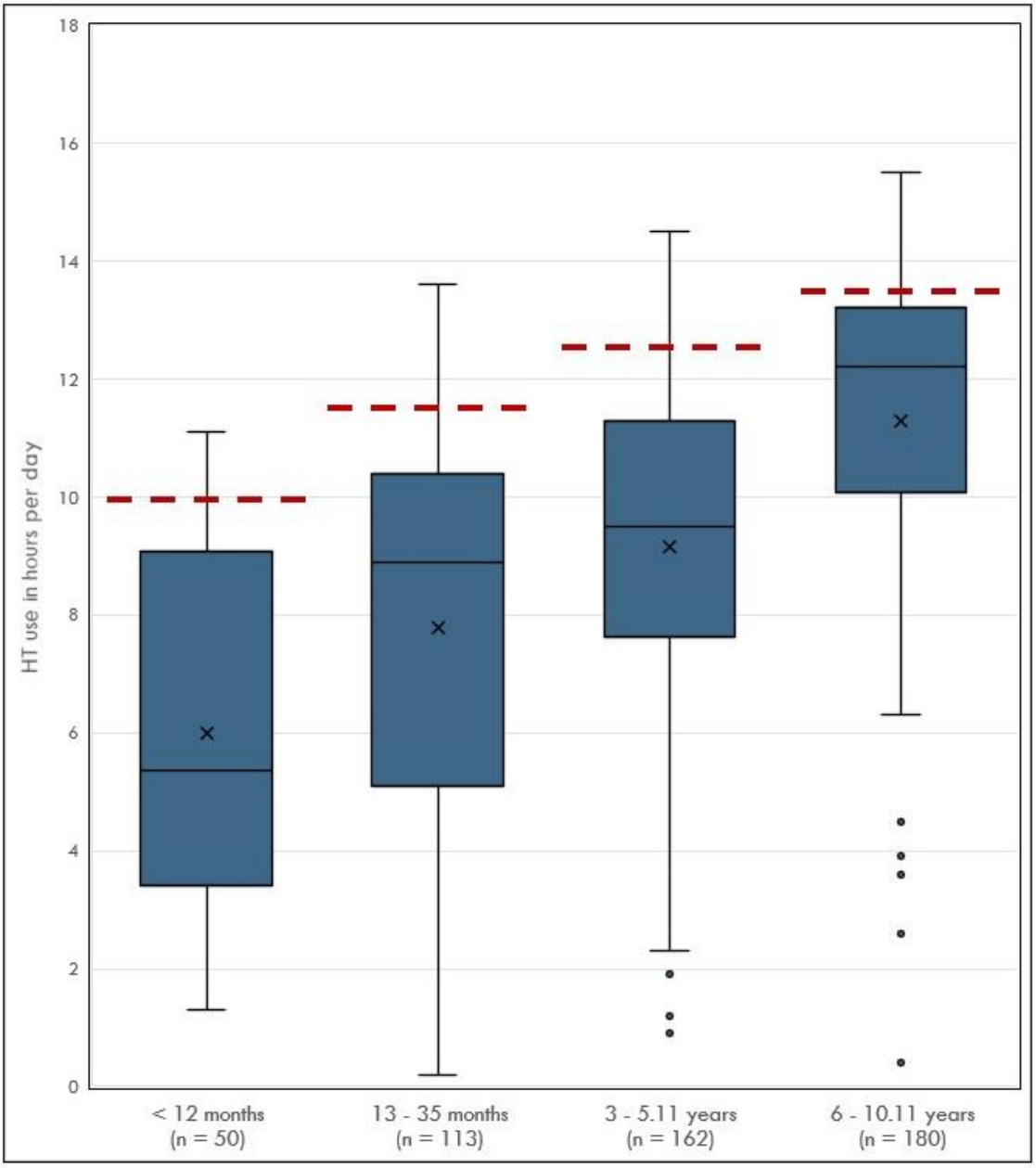
Finally, regression analyses were completed. Two general linear models (GLMs) were constructed to investigate the categorical and continuous predictors' influence on the continuous dependent variable. In the first GLM, all 31 significant predictor variables ($p < .01$) identified through both the ANOVA and the correlation analyses were entered into the model. Following this, the final GLM was built to generate predictive factors that simultaneously had the most significant effect on HT use. This final GLM model included all variables and was derived through a manual, step-by-step procedure. The model was run multiple times, systematically removing the non-significant variables with the highest *p*-value until the model was left with the only significant predictor. Throughout the entire regression analyses, a more conservative *p*-value was utilized to indicate statistical significance ($p < .01$), owing to the relatively large sample size and specificity of the research question. This *p*-value reduced the chance of false positives while simultaneously increasing the accuracy of any significant results obtained. In addition, four-way, three-way, and two-way interaction effects were performed on the final GLM to investigate the combined or interactive influence of the categorical variables on the dependent variable, HT use.

3.4 Results

Hearing Technology Use in Children

The 505 children included in this study demonstrated average HT use of 9.4 hours a day (3.4 *SD*, 0.2-15.5 hours a day range) and a mean HHP of 74.3% (25.5 *SD*, 1.7%-118.6% range). The mean period between the first and last data logging measure was 8.2 months of HT use (2.4 *SD*; 2-12 months range). Figure 1 demonstrates HT use (hours a day) across different chronological age groups and concurrent expected awake or hearing hours (Paruthi et al., 2016). Older age groups were associated with higher HT use approximating the awake time or hearing hours of children with normal hearing.

Figure 1. Average hearing technology use as a function of chronological age (*N* = 505).



The box plots represent HT use according to ages with the smallest observation, lower quartile, median (line), mean (x), upper quartile, largest observation, and the outliers (>1.5 times interquartile range = •). The dotted line indicates the expected median awake or hearing hours for each age group, as determined by the AASM (Paruthi et al., 2016).

Factors That Influenced Hearing Technology Use in Children

The bivariate analyses (ANOVA and CORR) indicated that 31 of the 42 potential prognostic factors included had a significant association with children's HT use. Table 5 summarizes the ANOVA analysis results (p <.01), and Table 6 condenses the CORR analysis results (p <.0.1).

The outcome variable was estimated using regression analyses (p <.01). The final GLM was highly significant (F (16,477) = 45.66; p < .01, R^2 = 0.605) and generated 10 significant predictor factors. Table 7 summarizes the 10 factors (seven categorical and three continuous variables) that emerged as significant predictors of HT use (n = 494). Simultaneous interaction of these factors included in the model accounted for 61% of the variance in HT use. When considering the categorical variables identified through the GLM, none of the four-way, three-way, or two-way effects was significant (p <.01).

Table 7. Linear regression analysis results of the final general linear model (n = 494).

GLM Predictors	*df*	Sum of Squares	Mean Square	*F* Value	Pr > F (*p*-value)	R^2
	16	3458.58	216.16	45.66	<.0001	0.605002
Type of HT fitting					<.0001	
Degree of HL					<.0001	
Older chronological age					<.0001	
Coordinated onsite audiological management					<.0001	
≥75% intervention attendance					<.0001	
Auditory-oral communication mode					<.0001	
Self-procured batteries					<.0001	
Child ability to independently use HT					<.0001	
Older age at HL diagnosis					0.0015	
Older age at initial HA fitting					0.0016	

df: degrees of freedom
Pr > F: p-value of the F test (with F-test testing the significance of the model)
R^2: determination coefficient

Table 8 summarizes the predictor estimates of the seven significant (p < .01) categorical factors generated by the final GLM. The effect of the type of HT fitting on HT use *(*p < .0001) could be predicted when comparing it to the reference, namely bilateral HA users. The highest HT use was predicted for bilateral CI users (72 minutes more), bimodal CI users (61 minutes more), and children fitted monaurally (either a CI or HA) but a bilateral hearing loss (18 minutes more). Children with unilateral hearing loss and monaural HT fitting (HA or BCHD) had the lowest average HT use. Their HT use on average was 68 minutes less than the children fitted with bilateral HAs. More severe degrees of hearing loss *(*p < .0001) were predictive of higher average daily HT use. HT use in children with profound hearing loss (>80 dB HL) was estimated the highest at 16 minutes more than the estimated parameter or reference, namely severe hearing loss (60-80 dB HL). A moderate hearing loss (30-60 dB HL) was associated with 65 minutes less daily use and a mild hearing loss (<30 dB HL) with 178 minutes less daily use compared to children with severe hearing loss. Coordinated onsite

audiological management *(p* < .0001) was associated with an increase in HT use of 74 minutes, compared to the HT use of children who received audiology services at other premises. Families with intervention attendance records of ≥75% *(p* < .0001) predicted increased daily HT use of 76 minutes, compared to those children from families with less than 75% caregiver intervention attendance. An auditory-oral communication mode *(p* < .0001) was associated with 79 minutes more daily use than a bimodal communication mode. When children required subsidized batteries *(p* < .0001), their HT use was reduced by 67 minutes per day. Lastly, children who independently used their HT *(p* < .0001) increased HT use by 64 minutes a day, compared to those who required adult assistance.

Table 8. Predictor estimates of the seven categorical predictor factors generated by the final general linear model (*n* = 494).

Independent Variable	Parameter	*n*	HT use		Estimate (*SE*)
			Mean (h/day)	*SD* (*95%CI*)	
Type of HT fitting	Binaural HAs	283	8.6	3.6 (8.2 - 9.0)	Reference
	Bilateral HL but monaural HT (CI/HA)	43	9.4	3.1 (8.4 - 10.3)	0.300 (0.365)
	Bimodal HT (CI and HA)	68	11.0	2.1 (10.5 - 11.5)	1.192 (0.343)
	Bilateral CIs	73	11.4	2 (10.9 - 11.9)	1.015 (0.372)
	Unilateral HL and monaural HT	27	7.5	3.2 (6.2 - 8.8)	-1.144 (0.445)
Degree of HL	Severe (61–80 dB HL)	121	9.7	3.3 (9.0 - 10.3)	Reference
	Normal (<26 dB HL)	9	5.1	3.3 (2.5 - 7.6)	-3.222 (0.761)
	Mild (26-30 dB HL)	6	6.1	2.8 (3.1 - 9.1)	-2.976 (0.923)
	Moderate (31–60 dB HL)	113	8.4	2.7 (7.9 - 8.9)	-1.086 (0.298)
	Profound (>80 dB HL)	253	9.9	3.5 (9.4 - 10.3)	0.265 (0.299)
Audiological management	Offsite premise	161	8.1	4.1 (7.4 - 8.7)	Reference
	Coordinated onsite	333	10.0	2.8 (9.7 - 10.3)	1.247 (0.229)
Intervention attendance	<75% caregiver adherence	221	8.1	3.6 (7.6 - 8.5)	Reference
	≥75% caregiver adherence	273	10.4	2.8 (10.1 - 10.7)	1.278 (0.229)
Communication mode	Auditory-oral	428	9.8	3.1 (9.5 - 10.1)	Reference
	Bimodal communication	66	6.3	3.9 (5.3 - 7.2)	-1.321 (0.342)
Batteries	Subsidized	184	7.8	3.6 (7.2 - 8.3)	Reference
	Self-procured	310	10.3	2.9 (9.9 - 10.6)	1.121 (0.234)
Independent HT user	Dependent on adult assistance	319	8.2	3.4 (7.8 - 8.6)	Reference
	Independent	175	11.5	2.3 (11.1 - 11.8)	1.069 (0.255)

Table 9 consolidates the predictor estimates of the three significant ($p < .01$) continuous variables identified by the final GLM. Older chronological age *(p* < .0001), older age at diagnosis *(p* = 0.0015) and older age at initial HA fitting *(p* = 0.0016) predicted increased HT use.

Table 9. Predictor estimates of the three continuous predictor factors generated by the final general linear model (*n* = 494).

Independent Variable	Age (months)		Estimate (*SE*)
	Mean	*SD* (*95%CI*)	
Chronological age	62.7	34.6 (59.7 - 65.8)	0.038 (0.004)
Age at HL diagnosis	30.1	22.0 (28.2 - 32.1)	0.053 (0.016)
Age at initial HA fitting	33.5	22.3 (31.5 - 35.2)	0.053 (0.017)

3.5 Discussion

This study is the first to investigate predictors of HT use in a heterogeneous group of children using various types of HT. Average HT use in this study (9.4 hours a day *M*; 3.4 *SD*) compared well with more recent reports indicating average HT use in children between 9-11 hours a day (Easwar et al., 2018; McCreery & Walker, 2017). HT use approximated the hearing hours of normal hearing peers (Paruthi et al., 2016). Still, it fell short of the indicated >10 hours a day HA use found to be the minimum required to demonstrate language development gains in pre-schoolers (Tomblin, Harrison, et al., 2015). Most children in this study did not use their HT all waking hours, which implies less equivalent auditory experiences than children with normal hearing (Flexer & Wolfe, 2020). Language development, literacy, and knowledge will be negatively influenced if insufficient quantities and qualities of auditory information reach the brain, causing non-optimal neural connections (Kral & Lenarz, 2015). The investigation into predictors of HT use and the reported poorer outcomes in children with hearing loss, regardless of Early Hearing Detection and Intervention (EHDI), can support strategies to maximize HT use for optimal auditory experiences (Cupples et al., 2018; Tomblin, Harrison, et al., 2015; Tomblin, Oleson, Ambrose, Walker, & Moeller, 2020).

Older chronological age was a strong predictor of increased HT use in this study sample. This finding was in agreement with previous reports indicating that older age influenced HT use positively in children (Easwar et al., 2016; McCreery et al., 2015; Wiseman & Warner-Czyz, 2018). Older children are awake longer and have more opportunities to have auditory experiences (Park et al., 2019). On the other hand, typical developmental stages can influence HT use negatively, for example, reduced head and trunk support (Gagnon et al., 2020), the mouthing stage (Walker et al., 2013), as well as challenging temperament or state (Easwar et al., 2016). Retention solutions for children of younger

ages in challenging situations such as car seats could combat some of the difficulty caregivers experience facilitating HT use.

Higher average HT use was also associated with more severe degrees of hearing loss. Previous studies also found a greater perceived need to use HT when children had less residual hearing (McCreery et al., 2015; Walker, McCreery, et al., 2015). By anticipating that children with unilateral and milder hearing losses may be at risk for reduced HT use, enhanced support can be provided timeously. This is especially true for slight/mild degrees of childhood hearing loss where the perceived need may be minimized because of residual hearing. Families should be counselled regarding the potential negative impact of unaided milder hearing losses on developmental outcomes, including speech and language, academic performance, social interaction, behaviour, and health-related quality of life (Fitzpatrick, Coyle, et al., 2019).

This study was the first to demonstrate that children with a bilateral hearing loss, using at least one CI as part of their HT fitting combination (including unilateral, bilateral, and bimodal CI users) demonstrated significantly higher HT use when compared to children fitted with other HT combinations. Children with unilateral hearing loss and monaural HA/BCHD demonstrated the least HT use. Although the degree of hearing loss and type of HT is directly related and co-dependent, there is a lack of evidence comparing HT use in children using HAs and CIs employing similar methodologies. While Marnane and Ching (2015) investigated HA and CI use through subjective reports in 3-year-old children, the current study included the entire spectrum of HT types (except for ear-level remote microphone systems), utilized objective data logging as an outcome measure, and had a broader age range. Marnane and Ching (2015) proposed that CI use in children is most likely higher than HA use because the degree of hearing loss influences the need to access sound more regularly. The results of this study could suggest an additional consideration. Paediatric CI recipients generally receive more intensive intervention and follow-up appointments (Fulcher et al., 2012), allowing more opportunities to support increased HT use. Conversely, children with unilateral hearing loss using HT and those fitted with bilateral HAs with mild to moderate-severe hearing loss are more likely to receive less intervention and support as they demonstrate the most residual capacity for auditory-based outcomes (Moeller & Tomblin, 2015b).

In this study sample, an auditory-oral mode of communication significantly predicted increased HT use in children. While Archbold et al. (2019) indicated that an oral mode of communication was predictive of full-time CI use, it was based on parental report and evidence has since suggested that, at least for HAs, parents overestimate HT use by up to 3.4 hours a day (Muñoz et al., 2014; Walker et al., 2013). Recently, De Jong et al. (2020) examined the influence of parental communication mode

on CI use in children where parental communication was indicated as either oral communication, a combination of oral communication and sign language, or only sign language. Their results showed that parents using only sign language or a combination of sign and oral language was associated with reduced CI use. The current study suggests that children using an auditory-oral communication mode rely on auditory access to communicate, possibly increasing HT use. In contrast, children using bimodal communication may rely on audition less; therefore, the need for HT use may be less. While it is best practice to adhere to the caregiver preference for communication mode in aural re/habilitation, prolonged language deprivation for children with continued reduced HT use must be limited (W. C. Hall, 2017). Bimodal communication should be promoted when full-time HT use is unattainable for families, bearing in mind that proficient sign language use could also be an unfeasible expectation for the family.

Regular caregiver intervention attendance also predicted increased HT use. While the positive impact of caregiver participation in aural re/habilitation on the language development of children with hearing loss is well known (Erbasi et al., 2017; Flexer & Wolfe, 2020), less is known about how caregiver adherence to intervention appointments could influence auditory-based outcomes. Although both attendance and caregiver participation in intervention were identified through bivariate analysis in this study, only regular attendance was included in the GLM. The reason for increased HT use with regular caregiver intervention attendance could be attributed to these caregivers being more committed to their children's needs by recognizing the benefit they receive from therapy. Additionally, these families receive more frequent reminders of the benefit of HT use when interacting with a therapist and may indicate more engaged families. This unique finding supports the call for more sensitive and specific measurement tools of parental involvement and insight into paediatric aural re/habilitation (Erbasi et al., 2017).

Access to coordinated onsite audiological management at the intervention centre instead of an offsite premise was considered a strong predictive factor of increased HT use in this study. Though caregivers prefer streamlined audiological and intervention services for ease and practicality (Athalye et al., 2015), this study is the first to suggest that the coordination of services can positively influence HT use. A collaborative service could allow daily (school) or weekly (intervention) collaboration with the audiology department to investigate and address subtle signs of problematic HT use. Additionally, an onsite audiology department could also implicitly advocate that HT use is essential and prioritized for auditory-based communication outcomes, resulting in increased HT use.

In this study sample, the children who required subsidized batteries due to socio-economic circumstances had reduced HT use compared to those able to self-procure. Although the study's

bivariate analyses identified several factors associated with socio-economic circumstances as predictive factors (p <.01, see Table 5 for more information), such as accessing public health care (p <.0001), monthly family income (p = 0.0005), receiving a social disability grant (p <.0005), food parcels recipiency (p <.0001), and transport subsidies (p <.0001), self-procurement of batteries was the only factor included in the GLM. This specific finding could be considered counterintuitive as subsidized batteries are supposed to make it easier for children to achieve better HT use, despite socio-economic status. However, Wiseman and Warner-Czyz (2018) cautioned that low-income households could experience more pressing needs than HT use, as well as access to fewer resources, such as time and support systems. The families selected for battery assistance may experience more significant challenges than what can be addressed by the donation, subsequently not causing the desired effect, which is prioritizing and maintaining their child's HT use.

Older ages at hearing loss diagnosis and initial HA fitting predicted increased HT use too. This surprising finding that later diagnosis and HA fitting predicted increased HT use is probably related to the characteristics and context of the study sample. Most studies about HT use in children are from high-income contexts with effective EHDI programs for early detection, diagnosis, and intervention of childhood hearing loss (Cupples et al., 2018; Moeller & Tomblin, 2015b). McCreery and Walker (2017) recognized the diminishing effect of later diagnosis on HT use due to effective EHDI implementation in their context. The impact of delayed hearing loss diagnosis and intervention on HT use in an LMIC, like South Africa, is less clearly understood. In this sample, only a third of the children received NHS, resulting in delayed overall diagnosis (29.9 *M*, 21.9 *SD*, 0-104 months range) and initial HA fitting (33.5 *M*, 22.4 *SD*, 1-105 months range). These results could indicate increased caregiver insight into re/habilitation's impetus when children are older due to visible developmental delays. Furthermore, an auditory-oral intervention site could lay the groundwork for prominent advocacy and action regarding optimized HT use to "catch up" on auditory experiences. However, this finding requires further investigation, especially in LMICs, where delayed diagnosis and intervention are typical.

Children in this study demonstrated increased HT use when they could handle and use their HT independently compared to those who needed adult assistance. While the positive influence of older chronological age on HT use has already been discussed, this finding could be the first to indicate that independent HT use positively influences the use of HT in children. This finding suggests that children can approximate higher HT use when not dependent on adult assistance anymore and could be regarded as the first step towards developing self-advocacy skills.

The clinical implications of the study can be summarized according to three actions. First, professionals could *anticipate* that certain children with hearing loss (such as bilateral HA users or those with unilateral, mild, or moderate degrees of hearing loss) would be at risk for limited HT use when compared to children with more severe degrees of hearing loss and those using at least one CI. In those cases, implementing immediate scaffolding strategies such as counselling and parent-to-parent support could have a positive effect. Secondly, predictors of HT use could be *manipulated* where possible to increase HT use, such as prioritizing coordinated onsite audiology services with intervention. Lastly, predictors that cannot be manipulated could be *mitigated,* such as chronological age, by incorporating multiple retention strategies for younger children. Consequently, this study's results could assist in guiding clinical services provided to children using HT and acquiring auditory-based communication outcomes.

To the authors' knowledge, the present analysis contributed the first investigation into objective HT use in children using various HT fitting configurations. Additionally, it is the first to consider a broader range of predictor variables across multiple dimensions to determine its influence on the use of HT in children. As a result, the study was able to comment on the use of different HT in children and identified predictors not previously described in the literature before. These include the type of HT fitting, an auditory-oral mode of communication, regular caregiver intervention attendance, coordinated onsite audiology management at the intervention site, self-procured batteries, older ages at hearing loss diagnosis and initial HA fitting, and the child's ability to use their HT independently. Additionally, because the study sample was diverse, unselected, and extracted from an LMIC, study results could be generalized to a broader population.

On the contrary, the multi-factorial influence of predictors on HT use was evident as factors not investigated still accounted for 39% of the sample's remaining variation. The study had additional limitations; for example, it could not create a distinctive type of HT fitting category for the children fitted with BCHD to be included in the multiple regression analyses. Further studies with more specific research questions and stringent inclusion criteria could address these, such as investigating the use of BCHD in children with chronic otorrhea.

3.6 Conclusion

Although HT use is a multi-factorial outcome measure, this study identified an extensive range of predictive factors that could predict and increase HT use in children. Intrinsic predictors of increased HT use in children included older chronological age, more severe hearing loss, and older ages at diagnosis and initial HA fitting. Extrinsic predictors of increased HT use identified included the child's ability to independently use HT, at least one CI as part of the HT fitting, coordinated onsite

audiological management, self-procured batteries, auditory-oral communication mode, and regular caregiver intervention attendance. While factors like the degree of hearing loss and chronological age cannot be manipulated or modified, identifying, and manipulating malleable predictors of HT use, such as caregiver intervention attendance and independent HT use, could positively influence children's developmental outcomes. This study identified a range of newly described predictor factors of HT use a diverse, unselected sample of children with hearing loss.

Disclaimer Statements

Contributors: None.

Funding: None.

Conflicts of interest: None.

Ethics approval: University Pretoria, Department of Humanities (HUM010/0219).

Acknowledgements:

We appreciate the children and families whose data made this project possible. We also thank the clinical staff at the Carel du Toit Centre, who supported data collection inadvertently while completing their daily tasks.

ORCID

De Wet Swanepoel https://orcid.org/0000-0001-8313-1636

Talita le Roux https://orcid.org/0000-0002-7900-9600

3.7 References

American Academy of Audiology. (2013). *American Academy of Audiology: Clinical practice guidelines: Pediatric amplification*. https://www.audiology.org/sites/default/files/publications/PediatricAmplificationGuidelines.pdf

Archbold, S. M., Nikolopoulous, T. P., & Lloyg-Richmond, H. (2009). Long-term use of cochlear implant systems in pediatric recipients and factors contributing to non-use. *Cochlear Implants International*, *10*(1), 25–40. https://doi.org/10.1002/cii.363

Athalye, S., Archbold, S., Mulla, I., Lutman, M., & Nikolopoulous, T. (2015). Exploring views on current and future cochlear implant service delivery: The perspectives of users, parents and professionals at cochlear implant centres and in the community. *Cochlear Implants International*, *16*(5), 241–253. https://doi.org/10.1179/1754762815Y.0000000003

Bagatto, M., Moodie, S., Brown, C., Malandrino, A., Richert, F., Clench, D., & Scollie, S. (2016). Prescribing and verifying hearing aids applying the American Academy of Audiology pediatric

amplification guideline: protocols and outcomes from the Ontario infant hearing program. *Journal of the American Academy of Audiology*, *27*(3), 188–203. https://doi.org/10.3766/jaaa.15051

Busch, T., Vanpoucke, F., & van Wieringen, A. (2017). Auditory environment across the life span of cochlear implant users: Insights from data logging. *Journal of Speech, Language, and Hearing Research*, *60*(5), 1362–1377. https://doi.org/10.1044/2016_JSLHR-H-16-0162

Cesur, S., Yüksel, M., & Çiprut, A. (2020). Data logging variables and speech perception in prelingually deafened pediatric cochlear implant users. *International Journal of Pediatric Otorhinolaryngology*, *133*, Article e110003. https://doi.org/10.1016/j.ijporl.2020.110003

Cupples, L., Ching, T. Y. C., Button, L., Seeto, M., Zhang, V., Whitfield, J., Gunnourie, M., Martin, L., & Marnane, V. (2018). Spoken language and everyday functioning in 5-year-old children using hearing aids or cochlear implants. *International Journal of Audiology*, *57*(S2), S55–S69. https://doi.org/10.1080/14992027.2017.1370140

Davis, A., & Hoffman, H. J. (2019). Hearing loss: Rising prevalence and impact. *Bulletin of the World Health Organization*, *97*(10), 646-646A. https://doi.org/10.2471/BLT.19.224683

De Jong, T., van der Schroeff, M., & Vroegop, J. (2021). Child- and environment-related factors influencing daily cochlear implant use. *Ear & Hearing*, *42*(1), 122–129. https://doi.org/10.1097/aud.0000000000000911

Easwar, V., Sanfilippo, J., Papsin, B., & Gordon, K. A. (2016). Factors affecting daily cochlear implant use in children: Datalogging evidence. *Journal of the American Academy of Audiology*, *27*(10), 824–838. https://doi.org/10.3766/jaaa.15138

Easwar, V., Sanfilippo, J., Papsin, B., & Gordon, K. A. (2018). Impact of consistency in daily device use on speech perception abilities in children with cochlear implants: Datalogging evidence. *Journal of the American Academy of Audiology*, *29*(9), 835–846. https://doi.org/10.3766/jaaa.17051

Erbasi, E., Hickson, L., & Scarinci, N. (2017). Communication outcomes of children with hearing loss enrolled in programs implementing different educational approaches: A systematic review. *Speech, Language and Hearing*, *20*(2), 102–121. https://doi.org/10.1080/2050571X.2016.1238611

Fitzpatrick, E., Cologrosso, E., & Sikora, L. (2019). Candidacy for amplification in children with hearing loss: A review of guidelines and recommendations. *American Journal of Audiology*, *28*(4), 1025–1045. https://doi.org/10.1044/2019_AJA-19-0061

Fitzpatrick, E., Coyle, D., Gaboury, I., Durieux-Smith, A., Whittingham, J. A., Grandpierre, V., Na, E., & Salamatmanesh, M. (2019). Service preferences of parents of children with mild bilateral or

unilateral hearing loss: A conjoint analysis study. *Ear & Hearing*, *40*(3), 671–679. https://doi.org/10.1097/AUD.0000000000000651

Flexer, C., & Wolfe, J. (2020). Auditory brain development and auditory verbal therapy. In W. Estabrooks, H. M. Morrison, & K. MacIver-Lux (Eds.), *Auditory-verbal Therapy: Science, research, and practice* (pp. 35–58). Plural Publishing, Inc.

Fulcher, A., Purcell, A. A., Baker, E., & Munro, N. (2012). Listen up: Children with early identified hearing loss achieve age-appropriate speech/language outcomes by 3 years-of-age. *International Journal of Pediatric Otorhinolaryngology*, *76*(12), 1785–1794. https://doi.org/10.1016/j.ijporl.2012.09.001

Gagnon, E., Eskridge, H., & Brown, K. (2020). Pediatric cochlear implant wear time and early language development. *Cochlear Implants International*, *21*(2), 92–97. https://doi.org/10.1080/14670100.2019.1670487

Hall, W. C. (2017). What you don't know can hurt you: The risk of language deprivation by impairing sign language development in deaf children. *Maternal and Child Health Journal*, *21*(5), 961–965. https://doi.org/10.1007/s10995-017-2287-y

Joint Committee on Infant Hearing. (2019). Year 2019 position statement: Principles and guidelines for early hearing detection and intervention programs. *The Journal of Early Hearing Detection and Intervention*, *4*(2), 1–44. https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1104&context=jehdi

Jones, C., & Launer, S. (2010). Pediatric fittings in 2010: The Sound Foundation Cuper project. In R. Seewald & J. Bamford (Eds.), *Sound foundation through early amplification: Proceedings of the 2010 international conference.* (pp. 187–192). http://www.phonakpro.com/content/dam/phonak/gc_hq/b2b/en/events/2010/Proceedings/Pho_Chap_12_Jones_Final.pdf

Kral, A., & Lenarz, T. (2015). How the brain learns to listen: Deafness and the bionic ear. *E-Neuroforum*, *6*(1), 21–28. https://doi.org/10.1007/s13295-015-0004-0

Marnane, V., & Ching, T. Y. C. (2015). Hearing aid and cochlear implant use in children with hearing loss at three years of age: Predictors of use and predictors of changes in use. *International Journal of Audiology*, *54*(8), 554–551. https://doi.org/10.3109/14992027.2015.1017660

McCreery, R. W., & Walker, E. A. (2017). *Pediatric Amplification. Enhancing auditory access*. Plural Publishing, Inc.

McCreery, R. W., Walker, E. A., & Spratford, M. (2015). Understanding limited use of amplification in infants and children who are hard of hearing. *Perspectives on Hearing and Hearing Disorders in*

Childhood, *25*(1), 15–23. http://successforkidswithhearingloss.com/wp-content/uploads/2013/07/Understanding-Limited-Use-of-Amp-in-Infants-and-Children-who-are-HOH-Sig-9-Perspectives-4_15.pdf

Moeller, M. P. (2000). Early intervention and language development in children who are deaf and hard of hearing. *Pediatrics*, *106*(3), e43–e43. https://doi.org/10.1542/peds.106.3.e43

Moeller, M. P., & Tomblin, J. B. (2015). Epilogue: Conclusions and implications for research and practice. *Ear & Hearing*, *36*(S1), 92S-98S. https://doi.org/10.1097/AUD.0000000000000214

Muñoz, K., Larsen, M., Nelson, L., Yoho, S., & Twohig, M. (2019). Pediatric amplification management: Parent experiences monitoring children's aided hearing. *Journal of Early Hearing Detection and Intervention*, *4*(1), 73–82. https://doi.org/10.26077/a049-v107

Muñoz, K., Preston, E., & Hicken, S. (2014). Pediatric hearing aid use: How can audiologists support parents to increase consistency? *Journal of the American Academy of Audiology*, *25*(4), 380–387. https://doi.org/10.3766/jaaa.25.4.9

Park, L. R., Gagnon, E., Thompson, E., & Brown, K. (2019). Age at full-time use predicts language outcomes better than age of surgery in children who use cochlear implants. *American Journal of Audiology*, *28*(4), 986–992. https://doi.org/10.1044/2019_AJA-19-0073

Paruthi, S., Brooks, L. J., Ambrosio, C. D., Hall, W. A., Kotagal, S., Lloyd, R. M., Malow, B. A., Maski, K., Nichols, C., Quan, S. F., Rosen, C. L., Troester, M. M., & Wise, S. (2016). Consensus statement of the American Academy of Sleep Medicine on the recommended amount of sleep for healthy children: Methodology and discussion. *Journal of Clinical Sleep Medicine*, *12*(11), 1549–1561. https://doi.org/10.5664/jcsm.6288

Statistics South Africa. (2016). *Community survey 2016 [Statistical release P0301]*. http:///www.statssa.gov.za

Statistics South Africa. (2018). Provincial profile: Western Cape. [Community Survey 2016. Report 03-01-07]. In *Statistics South Africa*. www.statssa.gov.zainfo@statssa.gov.za

Tomblin, J. B., Harrison, M., Ambrose, S. E., Walker, E. A., Oleson, J. J., & Moeller, M. P. (2015). Language outcomes in young children with mild to severe hearing loss. *Ear & Hearing*, *36*(S1), 76S-91S. https://doi.org/10.1097/AUD.0000000000000219

Tomblin, J. B., Oleson, J., Ambrose, S. E., Walker, E. A., & Moeller, M. P. (2020). Early literacy predictors and second grade outcomes in children who are hard of hearing. *Child Development*, *91*(1), e179–e197. https://doi.org/10.1111/cdev.13158

Walker, E. A., Holte, L., McCreery, R. W., Spratford, M., Page, T., & Moeller, M. P. (2015). The influence of hearing aid use on outcomes of children with mild hearing loss. *Journal of Speech,*

Language, and Hearing Research, *58*(5), 1611–1625. https://doi.org/10.1044/2015_JSLHR-H-15-0043

Walker, E. A., McCreery, R. W., Spratford, M., Oleson, J. J., Van Buren, J., Bentler, R., Roush, P., & Moeller, M. P. (2015). Trends and predictors of longitudinal hearing aid use for children who are hard of hearing. *Ear & Hearing*, *36*(1), 38–47. https://doi.org/10.1097/AUD.0000000000000208

Walker, E. A., Spratford, M., Moeller, M. P., Oleson, J., Ou, H., Roush, P., & Jacobs, S. (2013). Predictors of hearing aid use time in children with mild-to-severe hearing loss. *Language Speech and Hearing Services in Schools*, *44*(1), 73–88. https://doi.org/10.1044/0161-1461(2012/12-0005)

Wiseman, K. B., & Warner-Czyz, A. D. (2018). Inconsistent device use in pediatric cochlear implant users: Prevalence and risk factors. *Cochlear Implants International*, *19*(3), 131–141. https://doi.org/10.1080/14670100.2017.1418161

World Health Organization. (1991). *Report of the informal working group on prevention of deafness and hearing impairment programme planning, Geneva, 18-21 June 1991.*

World Health Organization. (2016). *Childhood hearing loss: Strategies for prevention and care*. http://www.who.int/about/licensing/copyright_form/index.html

World Health Organization. (2020). *Basic ear and hearing care resource*. World Health Organization. licence: CC BY-NC-SA 3.0 IGO. http://apps.who.int/iris

4. DISCUSSION AND CONCLUSION

This retrospective cohort study aimed to identify and describe predictors of HT use in children with hearing loss. Exploring HT use and the factors that influence it should be prioritized by paediatric audiologists since HT use is the one recommendation most widely offered to families with a child with hearing loss (Flexer & Wolfe, 2020; Health Professions Council of South Africa, 2018; Joint Committee on Infant Hearing, 2019). While HT use remains only partially implemented (McCreery & Walker, 2017), audiologists arguably consider it the most critical factor required to maximize a child with hearing loss's natural potential to use listening to develop desired auditory-based outcomes (Busch et al., 2019; Cesur et al., 2020; Flexer & Wolfe, 2020; Gagnon et al., 2020; Sininger et al., 2010; Tomblin, Harrison, et al., 2015; Tomblin, Oleson, Ambrose, Walker, & Moeller, 2020; Tomblin, Oleson, Ambrose, Walker, McCreery, et al., 2020; Wolfe & Neumann, 2016).

The present analysis was the first to consider a broader range of predictor variables extracted from a developing context, including variables that have not been studied in any context previously. Accordingly, the study successfully identified and described 10 highly significant predictors and their influence on the use of various HT in children. Additionally, four of the predictors, both novel and extrinsic, are malleable (Moeller & Tomblin, 2015), signifying that intervention can change the outcome, namely HT use. Furthermore, this study was one of the first studies conducted in a developing context and included different HT. Hence, this study contributed to the last decade's scientific body of evidence supporting evidence-based practices in childhood hearing loss (Bagatto et al., 2016; Buchman et al., 2020; Ching, Dillon, Leigh, Cupples, et al., 2018; Dillon et al., 2013; Moeller et al., 2013; Moeller & Tomblin, 2015b, 2015a; Ramsden et al., 2012; Sharma et al., 2020; Smith et al., 2015; Tomblin, Harrison, et al., 2015; Yoshinaga-Itano, 2014).

4.1 Summary of Research Findings

Hearing Technology Use in Children

This study investigated the predictors of HT use in a heterogeneous South African cohort of 505 children <11 years of age using various types of HT. Average HT use in this study (9.4 hours a day *M*, 3.4 *SD,* 74.3% HHP) compared well with more recent reports averaging HT use in children between 9 to 11 hours a day (De Jong et al., 2021; Easwar et al., 2016; Park et al., 2019; Persson et al., 2020), approximating the hearing (awake) hours of normal-hearing peers (Paruthi et al., 2016).

HT use in this sample surpassed the recommendation of full-time use, defined as 8 hours a day (Easwar et al., 2016; Walker, McCreery, et al., 2015; Wiseman & Warner-Czyz, 2018). However, it fell

short of the indicated >10 hours a day HA use found to be the minimum requirement to demonstrate language development gains in pre-schoolers (Tomblin, Harrison, et al., 2015). Additionally, all age groups included in this study sample fell short in reaching both the more recently suggested criterion of 80% HHP (Park et al., 2019) and the all-day "eyes open, ears on" endorsement regularly prescribed in clinical settings (Flexer & Wolfe, 2020, pg 52). Subsequently, this study reinforced the evidence from the last decade that children from various contexts and with a range of audiological configurations and HTs do not use their HT equivalent to the hearing hours of their typical hearing peers (De Jong et al., 2021; Easwar et al., 2016; Marnane & Ching, 2015; McCreery et al., 2015; Muñoz et al., 2018; Walker, McCreery, et al., 2015; Wiseman & Warner-Czyz, 2018). The results highlighted that the children in this study sample had potentially fewer hearing hours and resultant less auditory experiences than children with normal hearing. Less auditory experiences continue to be a concern for paediatric audiologists since knowledge and insight into the developing auditory brain are expanding while the implication of auditory deprivation becomes more delineated (Flexer & Cole, 2020; Gordon et al., 2003; Kral et al., 2016; Kral & O'Donoghue, 2010; D. R. Moore & Shannon, 2009; J. K. Moore & Linthicum, 2007). When insufficient quantities and qualities of auditory signals reach the brain, non-optimal neural connections occur that negatively influence language development, literacy, and world knowledge in children with hearing loss (Kral & Lenarz, 2015).

Predictors of Hearing Technology Use in Children

The study examined 42 categorical and continuous variables across different domains (demographic, family, intervention, socio-economic, audiology and HT-related). Firstly, bivariate analyses (p <.01) identified 31 of the included variables as statistically significant predictors of HT use. Secondly, multi-regression analyses identified 10 interacting variables (p <.01, R^2= 0.605) predicting increased HT use. Intrinsic predictors of increased HT use included a more severe degree of hearing loss, older chronological age, older age at hearing loss diagnosis, and older age at initial HA fitting. Extrinsic predictors included the child's ability to independently use HT, using at least one CI as part of the HT fitting, coordinated onsite audiological management, self-procured batteries, an auditory-oral communication mode, and regular caregiver intervention attendance. Additionally, four of the predictors, both novel and extrinsic, are malleable. Moeller and Tomblin (2015) defined malleable factors as any child- or family-specific variables that can be amended as it has the potential to change as part of the intervention.

The complexity of the outcome variable, namely HT use, was recognized when 42 variables across various domains were included and analysed using multiple statistical adjustment procedures. Still, the 10 variables generated by the GLM analyses only accounted for 61% of the variation.

4.2 Clinical Implications

One of the primary reasons clinical audiologists engage in research is to safeguard the delivery of evidence-based audiology services while enabling their patients to achieve the best possible outcomes (Boisvert et al., 2017; Nelson, 2017). The clinical recommendations of this study are discussed according to three themes: HT use in children, predictors of HT use in children, and clinical implications for LMICs and other resource-constrained settings.

Hearing Technology Use in Children

The average HT use reported in this study (9.4 hours a day), together with its corresponding HHP (74.3%), indicated a daily deficit in hearing hours of 1 to 4 hours a day or 10% to 40% compared to peers and depending on age. This finding illustrates that partnering with families is a complex journey, that each family and their road is unique, and that audiologists require a comprehensive approach with various strategies to facilitate optimal spoken language outcomes in children with hearing loss. Subsequently, the implications of this research finding suggest that audiologists could expand their thinking and practice in addition to typical service delivery. The results from this study provide two added solutions to clinical practice –*intensifying* and *compromising* expectations of HT use in children.

Firstly, it could be a call to intensify audiologists' efforts promoting full-time HT use to facilitate auditory-based communication outcomes. Consequently, this can direct audiologists to recommend increasing the *quantity* of hearing hours or auditory experiences by increased HT use. The result could suggest that regular and ongoing monitoring, collaboration, and coaching of families are required to foster optimal HT use in children with hearing loss. Therefore, data logging information should be accessed more easily and frequently by parents and professionals (Muñoz et al., 2017). While hands-on and face-to-face consultation has significant value for families raising children with hearing loss, recent eHealth solutions offer novel opportunities to support parents with HA management (Muñoz et al., 2017; Muñoz, Nagaraj, et al., 2020; Whicker et al., 2020). Muñoz and colleagues demonstrated that virtual visits allowed data logging records to be collected more frequently, allowing for practical problem-solving and increased HA use by 7 to 10.5 hours a day over six months. More recently, they also found that their eHealth program resulted in significantly greater gains in the knowledge, confidence, perceptions, and monitoring skills related to HA

management of caregivers (Muñoz et al., 2021). This current study supports the calling for higher expectations of full-time HT use, a minimum of 10.5 to 13.5 hours a day, depending on age (Gagnon et al., 2020; Park et al., 2019). Audiologists can be encouraged to define and label all-day HT use in corroboration with developmental ages and respective awake hours (Galland et al., 2012; Paruthi et al., 2016) when collaborating with families to achieve age-equivalent auditory-based outcomes. A discussion about potential ways in which the quantity of hearing hours through HT use can be increased will follow in the next section (Table 10).

Secondly, the study results are also in agreement with McCreery and Walker (2017), who cautioned that all-day HT use is an unreasonable goal for families. This argument alludes to conceding that children's HT use cannot equate to their peers' hearing hours. In other words, audiologists could recognize that HT use will remain less than the hearing hours of hearing peers and that reduced use with ensuing reduced cumulative auditory experiences could possibly result in reduced auditory-based communication outcomes. Consequently, this can guide audiologists to focus their recommendations on promoting HT use on the quality of hearing hours and auditory experiences, rather than just the quantity of hearing hours through HT use (In other words, use HT when it matters). Furthermore, results could give audiologists supportive evidence to counsel families that while age-appropriate spoken language outcomes are desired, achieving it based on full-time use is an unrealistic expectation. Audiologists can be encouraged to pro-actively recommend language and literacy scaffolding techniques to combat childhood hearing loss's pervasive effects on communication, literacy, and social-emotional well-being. The study's findings of HT use in children could remind the child's intervention team that comprehensive paediatric hearing care remains critically important. Specifically, the journey to auditory-based communication outcomes does not end with detection, diagnosis, and fitting of HT. Instead, it is a lifelong journey of re/habilitation (Ekberg et al., 2020; Erbasi et al., 2018; Hawley et al., 2017; Joint Committee on Infant Hearing, 2019; Khoza-Shangase, 2019; Muñoz, Price, et al., 2019; Tomblin, Oleson, Ambrose, Walker, & Moeller, 2020).

Predictors of Hearing Technology Use in Children

The current study results can empower audiologists with clinical applications or enablers that could intensify their efforts to increase HT use by focusing on three actions. First, audiologists could *anticipate* that some children could be at risk for limited HT use. Secondly, audiologists could *utilize* some of the extrinsic factors that were identified to create more enabling environments. Thirdly, audiologists could *mitigate* intrinsic factors that cannot be manipulated. Table 10 summarizes the clinical enablers of the predictor factors of HT use by highlighting each factor and providing possible

corresponding actions. While these corresponding actions suggested are not a direct consequence of the findings of the study, it is supported by evidence, and can guide audiologists in their thinking and service provision.

Table 10. Factors that could reduce hearing technology use in children and corresponding actions to enable increased HT use.

Predictor of reduced HT use in children	Clinical actions to combat predictive factors of reduced HT use
Younger chronological ages	Multiple age-related issues can influence HT use in children, including retention, parental emotional concerns, internal barriers, parent decision making and behaviour or temperament challenges. Audiologists could pre-emptively employ specific retention strategies for particular age groups to allow for consistent use, such as pilot caps during the developmental stage of mouthing and during positional challenges such as car seats or prams (Blaiser & Thompson, 2019; Muñoz et al., 2014, 2016; Wiseman & Warner-Czyz, 2018). An onsite retention library at the audiology clinic, where families can see and trial different retention solutions available (Anderson & Madell, 2013), would be more empowering than advising families to do their own research and find what works for them. Alternatively, HT manufacturers could build partnerships with specific retention-solution companies and provide these solutions as part of the HT fitting package. Parent emotions such as grief, remorse or distress can play a prominent role in how enabled caregivers start and continue the re/habilitation journey with younger children (Meibos et al., 2016; Muñoz et al., 2016; Scarinci et al., 2018). For example, it is quite normal for the child to cry and wriggle during the containment required for easy HT placement with younger children. This distress by the child can potentially alarm caregivers that they are hurting their child or that the child rejects the HT (Muñoz et al., 2015). Experiences such as these can cause emotional distress to caregivers when they do not react in a way they anticipate or desire. Additionally, the use of HT can be interpreted as an outward manifestation of an invisible disability. It can make the adjustment and acceptance of the hearing loss and use of HT harder (Khoza-Shangase, 2019). Moms and tots groups are critical to assist and normalise this process for parents (Fulcher et al., 2012) and regular interaction with other older children using HT and their families (Peters & Anderson, 2019). Audiologists are encouraged to create continuously safe spaces for caregivers to share their fears and feelings without feeling criticized (Muñoz, Edelman, et al., 2020). This can be especially relevant to caregivers with younger children. The reader is advised to refer to Table 1, page 13 of this dissertation, based on the American Academy of Sleep Medicine guidelines and endorsed by the American Academy of Paediatrics (Paruthi et al., 2016), where expected awake or hearing hours per age is tabulated.
Children who do not use a CI as part of their HT fitting combination	The results from this study do not imply that children should become bimodal users to improve HT use. Instead, the clinical implication could be that the quantity and quality of audiological services to children with HAs and their caregivers and those with a CI need to be comparable (Moeller & McCreery, 2017).

Predictor of reduced HT use in children	Clinical actions to combat predictive factors of reduced HT use
Children with unilateral, mild to severe hearing losses	Implementing frequent, longer-term monitoring of HT use could be required for those children with unilateral or milder degrees of hearing loss or those who do not use a CI (Ambrose et al., 2020; Muñoz, Larsen, et al., 2019; Walker, 2020). The importance of incidental listening (Guerzoni & Cuda, 2017; Walker, McCreery, et al., 2015), hearing over distance (E. Thompson et al., 2020; Walker, 2020), and listening fatigue (Bess et al., 2020; Hoffman et al., 2019; Walker, 2020) could be re-emphasized. Counselling and interaction with these children and their families can be amended to increase awareness of the detrimental effects of inconsistent HT use. Additionally, specific simulations demonstrating the effect of HT use in these challenging listening environments could enhance caregiver's insight and motivation to encourage full-time HT use (Ambrose et al., 2020; Tran et al., 2016).
Children whose hearing loss was diagnosed earlier/ at a younger age Children who had their initial HA fitting earlier/ at a younger age	Audiologists have various counselling strategies (American Speech-Language-Hearing Association, 2008; Meibos et al., 2016; Muñoz et al., 2014; Preston et al., 2017; Weston et al., 2014) that can be applied for different scenarios such as earlier and later identified children. Families with earlier identified children could receive reassuring informational counselling messages such as “we got it in time” (Muñoz et al., 2017; Whicker et al., 2019). On the other hand, families with later diagnosed children could receive explicit directive messages such as “everyday matters, no time to waste”(Appenzeller & Ambrose, 2020). This directive counselling method (Watermeyer et al., 2017) could be employed for all children, regardless of ages at diagnoses and HA fitting, motivating families to establish consistent HT use quicker. More regular confirmation of what the family interpreted as the unspoken message conveyed during counselling could be necessary for families with children diagnosed earlier (Tran et al., 2016). Furthermore, when infants start using HT at a young age and present with, for example, 8 hours of daily HT use, at the first follow-up consultation, the appropriate message shared with the family could be that they have made an excellent start using HT (Scarinci et al., 2018). However, counselling that HT use should increase with age is potentially not discussed explicitly or monitored regularly. It is possible that the priority of aural re/habilitation is not as clearly defined with children who were earlier diagnosed and timeously fitted than with children who were diagnosed and fitted later (Walker et al., 2014). Priority could be given to accelerating initial HA fitting and enrolment in intervention for both early and late-diagnosed children, which in turn supports HT use to develop auditory-based communication outcomes.
Irregular caregiver intervention attendance	Reasons should be explored to determine why intervention session attendance is irregular for certain families (Brough & Kachaje, 2020) and what support strategies could enable these caregivers to increase attendance (Davids et al., 2021; Kanji, 2018; Watermeyer et al., 2017). A solution could include those clinical services to be adjusted to complement caregivers' work hours and methods of transportation. Investigation into alternative methods that ensure regular caregiver intervention attendance is recommended. Tele-intervention holds significant promise of easy to access aural re/habilitation services, especially for families with available data, high-speed internet, and computer screens that allow for equivalent therapy sessions (Bush et al., 2014; Govender & Mars, 2017; Havenga et al., 2017; Kanji, 2021; McCarthy et al., 2019). Investigation into how tele-intervention models could be practical, sustainable, and provide equivalent auditory-based communication outcomes in settings where data, connection speed, and functional screens are not available, could also be considered (Havenga et al., 2017).

Predictor of reduced HT use in children	Clinical actions to combat predictive factors of reduced HT use
Different sites for intervention and audiology management	Coordinated same-site audiology and intervention services could be prioritized and established (Alduhaim et al., 2020; Ching, Dillon, Leigh, Cupples, et al., 2018). In turn, such an arrangement could both improve caregiver intervention attendance and provide additional opportunities to monitor HT use in children with hearing loss. Alternatively, different-site audiology and intervention services will need to connect more purposefully and regularly. The rapid development of eHealth and communication solutions can play an active part in building more effective collaboration (Muñoz et al., 2017; Nickbakht et al., 2020). This can include coordinated message groups on instant message platforms such as WhatsApp and online chats (Davids et al., 2021; Nickbakht et al., 2020).
Depending on adult assistance to insert and use HT	Purposively empowering younger children to ask for assistance and subsequently insert and use their HT independently could develop self-advocacy skills and increase HT use (Klein et al., 2019; Kleinert et al., 2010). Caregivers could be encouraged to have developmental targets for independent use for children (Kleinert et al., 2010; Muñoz et al., 2017). For example, it can be appropriate for 12- to 18-month-old toddlers to position the coil independently, with a hand-over-hand strategy. Children from 24 months and older could be encouraged to do the earmold's last little push into the ear canal to ensure a snug fit. Children who are 30 months and older could be responsible for positioning the behind-the-ear HA on the pinna after caregivers have inserted the ear mould. The development of independence of HT care (Klein et al., 2019; Page et al., 2018) can lay the foundation for the early development of self-advocacy and self-determination skills. This way, children with hearing loss can be empowered to be actively involved in attaining their educational, vocational, and social-emotional ambitions (Kleinert et al., 2010). Another point central to this factor could be caregivers' emotional state and motives; determining their capabilities to understand their child's HT use depends on their actions. Caregivers face multiple challenges that can interfere with HT use, such as managing challenging child behaviour (resistance to insertion), gaining confidence with HT use, as well as fear about how others will react to their child (Muñoz et al., 2015; Muñoz, Price, et al., 2019). These emotional states can influence their capability to insert and use HT for children depending on their assistance. Targeted caregiver support to optimize HT use, especially through telehealth applications, could purposefully address the needs of families (Muñoz et al., 2017).
Subsidized batteries required	Audiologists could identify families who need subsidized battery stock early in the audiological re/habilitation process and continue fostering regular engagements and support about effective battery procurement (Lasisi et al., 2006). Within the study's context, the Department of Health's audiology clinics use a protocol where six depleted battery cells can be exchanged for six fresh ones. However, caregivers need to have time and transport to travel to a primary healthcare clinic, possibly suggesting that there will be a time when the child is without access to their HT. Families eligible for subsidized batteries could receive bulk stock or be allowed to retrieve additional stock at their convenience before their current stock is depleted. The availability of rechargeable batteries in paediatric HAs (Freeman, 2017; Johnson, 2017) could improve regular HT use without relying on the procurement of battery cells anymore.

Predictor of reduced HT use in children	Clinical actions to combat predictive factors of reduced HT use
Bimodal communication mode	Communication mode is fluid in the early years of children with hearing loss ((M. L. Hall, 2020; Kushalnagar et al., 2010; Thomas & Zwolan, 2019; Watson et al., 2006), with the developmental outcomes determined by audibility, early intervention and family expectations. The development of listening and spoken language is founded on audibility (Flexer & Wolfe, 2020; Percy-Smith, Tønning, et al., 2018; Wolfe & Neumann, 2016). Families need to grow in their understanding that to achieve this desired goal, optimal HT use is essential. This can be achieved by parent-to-parent meetings, mentoring, and purposeful partnerships with older children who are successful HT users and auditory-based communicators (Hintermair et al., 2018). Unbiased information about access to language without HT should be shared with families to foster understanding of the benefit of bimodal communication (Moeller et al., 2013; Rhoades, 2018). When all-day HT use cannot be implemented timeously, and with ease, access to bimodal-bilingual communication should be provided (Fitzpatrick et al., 2013, 2016; W. C. Hall, 2017; W. C. Hall et al., 2017).

Clinical Implications for Low- and Middle-Income Countries and Other Resource-Constrained Settings

While the higher prevalence of childhood hearing loss in LMICs is well documented (Desalew et al., 2020; World Health Organization, 2021), the lack of availability and access to general hearing health care is well known. Specifically, paediatric audiological rehabilitation, aural re/habilitation, or any communication intervention, remain unaddressed (Khoza-Shangase & Kanji, 2021; McPherson, 2014; Peer, 2015). As a result, there is limited evidence of appropriate contextual management strategies for childhood hearing loss (Kanji, 2021).

Firstly, this study results indicated that HT use of children from LMICs is similar to their peers from high-income countries, suggesting that similar HT use expectations can be achieved despite living in a developing context. This contrasts with divergent opinions that HT fitting and auditory-based communication intervention in children with hearing loss are not appropriate management strategies for resource-constrained contexts (Adedeji et al., 2015; Asoegwu et al., 2019; Fobi & Oppong, 2019; Lutalo-Kiingi & De Clerck, 2017; Maluleke et al., 2021).

Secondly, even though multiple variables related or relevant to the child's socio-economic status were included in the data analyses (factors such as type of access to healthcare, transport subsidy recipiency, food parcel recipiency, family income, travelling distance to the intervention program, social disability grant recipiency and maternal and paternal level of education), the GLM only identified one statistically significant predictive factor of HT use related to socio-economic status,

namely self-procured batteries. This could possibly indicate that typical factors linked to socio-economic characteristics or more prevalent in LMICs, such as lower maternal education, are not as predictive of limited HT use in LMICs as in HICs (Walker et al., 2013). This critical differentiation requires more investigation.

Thirdly, identifying multiple extrinsic predictors that can positively influence auditory-based communication outcomes in settings where resources are limited and childhood hearing loss is, on average, diagnosed later is especially relevant to LMICs. Subsequently, it could be pertinent to direct limited resources available towards these factors, or enablers such as regular caregiver intervention attendance, when providing family-centred early intervention (English et al., 2017; Kanji, 2021; Moeller et al., 2013; Singh et al., 2017). For example, consider a family that discloses inflexible work hours as the primary barrier to regular intervention attendance. In that case, an alternative time slot could be created by employing professionals with flexible work hours that align with the family's availability (Holzinger et al., 2011; Maluleke et al., 2021; McCarthy et al., 2019). The benefit of family engagement and participation in re/habilitation is well known (Alduhaim et al., 2020, 2021; Ekberg et al., 2020; Harrison et al., 2016), and regular caregiver attendance of these sessions has now also been demonstrated to increase HT use in children.

4.3 Critical Evaluation

Research is not only a methodological process of collecting, analysing, and interpreting information to improve our understanding of an occurrence; it is also an exercise in developing critical thinking and establishing academic integrity (Carruthers, 2019). Academic integrity requires both a well-designed and executed study with appropriate interpretation, and especially completing a critical evaluation of the attempt (Leedy & Ormrod, 2020).

Strengths of the Study

The identified strengths of the current study are discussed below.

- The present analysis contributed the first investigation into objective HT use in children using various HT fitting configurations, comparing children's use of different HT such as HAs, CIs, and BCHDs. Only ear-level remote microphone classroom systems such as the *Phonak Roger* or *Oticon Amigo Star* were excluded as this type of technology is aimed at specific learning or listening environments and not devices that are generally used throughout the child's day. HA users in this study included children fitted with both behind-the-ear and receiver-in-the-canal HAs, and CI users comprised children fitted with behind-the-ear and off-the-ear CI speech processors. The

BCHDs were worn on either soft bands, abutments, or subcutaneous magnets. Furthermore, HT from various HT manufacturers was included, namely *Advanced Bionics*, *Cochlear*, *Med-El*, *Phonak*, *Oticon*, *Resound*, *Rexton*, *Siemens*/*Signia*, *Unitron*, and *Widex*, all with different data-logging algorithms. While there may be minor differences in how HT use was reported in the respective HT software applications, incorporating multiple HT manufacturers added generalizability to the results. As a result, the study was the first to report on the use of different HTs in children using the same methodology.

- Additionally, this study is the first to consider a broader range of predictor variables across multiple dimensions to determine its influence on the use of HT in children. The retrospective chart review identified and incorporated 42 suspected predictive factors access different domains in the regression analyses. As a result, various independent variables previously undescribed in the literature could be included in the regression models. Consequently, the study identified six novel factors that predicted HT use in children, such as independent HT use, self-procured batteries, same-site audiological management, later diagnosis and initial HA fitting and CI use. These novel extrinsic predictors hold particular interest as it is malleable (McCreery & Walker, 2017), suggesting that the child- and family-specific variables could be amended in clinical practice to influence developmental outcomes in children.

- Another strength of this study is that it included the first data from a developing context about HT use in children with hearing loss. Specifically, it incorporated children whose hearing loss was diagnosed early and late according to EHDI guidelines (Health Professions Council of South Africa, 2018; Joint Committee on Infant Hearing, 2019). Available research about HT use in children with hearing loss primarily originates from Northern America (Easwar et al., 2016; Ganek et al., 2020; Tomblin, Walker, et al., 2015) and Australia (Ching, Dillon, Leigh, & Cupples, 2018; Dillon et al., 2013). While the results mentioned above are valuable, it is difficult to generalize to LMICs like South Africa. As more than 80% of infants with hearing loss are born in LMICs (World Health Organization, 2021), the current investigation could be more generalizable or applicable to similar contexts.

- The outcome variable, namely HT use, was utilized as an objective measurement (data logging) rather than a subjective report, increasing the validity of the data (Krefting, 1991). Furthermore, HT use was determined as an average of multiple measurements collected over time (8.2-month data period *M*, 2.4 *SD*, 2-12 range). Multiple measures increased the likelihood of an actual reflection of HT use for a particular child (Leedy & Ormrod, 2020). A single measurement over

time could be influenced by many variables, such as faulty equipment or time in repairs (Klein et al., 2019).

- Furthermore, the study sample was heterogeneous and relatively large when compared to other reports of HT use in children and the predictors thereof (Ambrose et al., 2020; Cesur et al., 2020; Easwar et al., 2018; Gagnon et al., 2020; Guerzoni & Cuda, 2017; Gustafson et al., 2017; Park et al., 2019; Persson et al., 2020; Walker, McCreery, et al., 2015; Wiseman & Warner-Czyz, 2018). It included a broad spectrum of children with all types and degrees of hearing loss and HTs, children from diverse educational settings, and public and private health care sectors. This retrospective cohort study's power calculation was high ($\alpha = 1$) with an effect size of 1.5, ensuring that both the significant and non-significant findings were robust, suggesting that the study had replicability and that the research question could be answered.

Limitations of the Study

An essential aspect of a critical evaluation of the study is alerting readers to the study's possible weaknesses (Leedy & Ormrod, 2020). Several limitations of this study need to be acknowledged:

- There was no randomization or intervention; thus, no causal relationships between predictors and HT use could be ascertained. Retrospective cohort studies generally fall into a category of cohort or case-control studies (level of evidence = IV), which are typically judged inferior to preferred randomized control studies when evaluating the quality of a study (Abbott et al., 2016).

- The use of 42 variables included may appear to be extensive, but some authors have divergent opinions about including a relatively large number of variables in one investigation. Mertler et al. (2016, p. 121) suggested that researchers should be careful to incorporate too many variables in an attempt to identify some association and that such an attempt could be considered a "fishing expedition" if the variable selection is not executed cautiously. On the other hand, failure to include the proper variables in the regression analyses could provide inaccurate results, failing to identify the true relationship that exists in the data between the outcome and possible predictor variables (Chowdhury & Turin, 2020; Dunteman & Ho., 2006). Subsequently, this study attempted to employ multiple safeguards to uphold the scientific integrity and validity of the results (Abbott et al., 2016; Mertler, 2016). The large number of categorical and continuous variables included in this study were offset by using sound statistical support and applying multiple statistical adjustment procedures. The statistical analysis completed bivariate analyses between each variable and the outcome variable, HT use. Additionally, a more conservative *p*-value was utilized to indicate statistical significance ($p < .01$), owing to the relatively large sample size and specificity

of the research question (Chowdhury & Turin, 2020). Furthermore, a formal variable selection method, a manual, step-by-step procedure, was employed for the final GLM, allowing examination of different combinations of variables that otherwise may have been overlooked (Dunteman & Ho., 2006; Faraway, 2016). This statistical method is also considered comparatively independent as the same variables are usually selected from the same data set even when different individuals are conducting the analysis (Chowdhury & Turin, 2020). By including these steps, the study attempted to allow for reproducibility and validation of the GLM, despite the high number of independent variables.

- Like the GLM model used in this study, statistical models are never perfect because of the researcher's limitations (Leedy & Ormrod, 2020). In this case, the researcher's limitations could have included an incomplete understanding of the variables, inaccuracies in how variable interactions were modelled, and the cumulative effect of minor errors in the model's initial calculations. Indeed, multiple prediction models could have been utilized in this study investigating predictors of a dependent variable (Bouwmeester et al., 2012; Faraway, 2016; Leedy & Ormrod, 2020). For example, a general linear mixed model could have been employed as longitudinal data was used to determine the outcome variable, namely HT use. Additionally, mixed-effects models are useful when accounting for both inter-and intra-variability when a single measure of residual variance cannot account for both (Faraway, 2016; Pekár & Brabec, 2018). However, as this study used a single averaged continuous variable calculated with the collected longitudinal data, the GLMs were considered appropriate. Secondly, the GLM was deemed to be suitable for this study because there is no relationship between the children in terms of usage of the devices. The condition or environment in which the children were using their HT was independent for each child. Therefore, as the environments were diverse during HT usage for each participant, a GLM was considered a more appropriate method.

- The clinical management of children with hearing loss in this study sample included counselling and potential interference of HT use. Thus, if poorer than expected HT were noted, the managing audiologists would have addressed it at the time. This could have potentially resulted in improvements over time, biasing the data (Yuan et al., 2021). In other words, even though this was an observational study, the continuous dependent variable HT use was an average of data collected over time, and the audiological management of the child at the intervention program could have influenced it (Walliman, 2011).

- Lastly, despite the inherent strengths of the study sample, such as size, power calculation, and representativeness of the socio-economic distribution of South African children, there were also

study sample limitations. The study employed non-probability convenience sampling to sample children from the intervention program promoting auditory-based communication outcomes. The most significant disadvantage when using non-probability convenience sampling is that it is impossible to know how well the general population is represented, limiting true generalization (Etikan et al., 2016). Spoken language as a communication mode is not an available option to all children with hearing loss growing up in LMICs. This is noticeable even in South Africa, where not all children with hearing loss have equal access to the HT, intervention and support required to develop auditory-based communication (Khoza-Shangase & Kanji, 2021). Therefore, while auditory-based outcomes were a realistic goal for this study's participants, it is not the case for all children with hearing loss growing up in developing contexts. Subsequently, it could imply that children fitted with HT who use only South African Sign Language as their mode of communication were not equally represented in the study sample. On the other hand, most children who only communicate using South African Sign Language do not use HT (Kara & Harvey, 2017; Mitchell, 2016; Stander, 2019; Weir & Ayliff, 2014), and thus, the study results would not apply to them.

4.4 Future Research Recommendations

Leedy and Ormrod (2020) argued that most research studies create additional research questions to be answered rather than bring closure to an initial research question. This is also true for the current research and led the researcher to identify the following recommendations for further investigation relevant to HIC and LMICs.

- All the novel extrinsic predictive factors of HT use identified in this study have malleability, that is, child- or family-specific factors that are amenable to change (Moeller & Tomblin, 2015). McCreery and Walker (2017) stated that malleable predictors hold promise for improved evidence-based services as these factors can be manipulated to influence outcomes in children with hearing loss. Further investigation into how the novel extrinsic predictors identified in this study could be manipulated to become enablers of increased HT use is recommended. For example, consider the extrinsic factor of independent HT use in children. No evidence is available about this skill and the developmental stages children go through becoming independent users of HT. Research into what insertion techniques to teach to children at what developmental ages could positively influence HT use.

- As data logging offers precise, recorded data, it could help define HT-associated outcomes in children with hearing loss. Future studies could utilize data logging and explore its relationship

with other childhood developmental domains, such as vestibular, emotional, and cognitive outcomes in children with hearing loss. Establishing such relationships may provide additional evidence for the efficacy of HT in children with hearing loss.

- Presently eHealth solutions relevant to paediatric audiology are evolving rapidly (Glista et al., 2021; McCarthy et al., 2019; Muñoz, Nagaraj, et al., 2020; Steuerwald et al., 2018; Whicker et al., 2020). Investigating how mHealth applications can act as monitoring and motivational tools to caregivers and children could add to the understanding of what caregivers and older children require to support HT use.

- The need to develop quality caregiver educational material providing appropriate and unbiased information on childhood hearing loss has been highlighted previously (Ambrose et al., 2020; Meibos et al., 2016; Whicker et al., 2020). Likewise, there is a lack of clinical tools, objects, and concrete, contextually appropriate, evidence-based simulations when discussing HT use in children with families (Appenzeller & Ambrose, 2020; Joubert & Githinji, 2014). The development and comparison of different tools that are potentially not based on literacy (such as video or visual infographic tools) could be explored to determine the influence on HT use over time. Investigation into standardized visual communication tools could also enhance counselling provided to families.

- This study used data from 2010 to 2018 when CI speech processors had the standard option to function with either rechargeable batteries or disposable batteries. Still, rechargeability options for children fitted with HAs were non-existent at that time. Further investigation into recent developments of rechargeable HAs for children could add to our understanding of the impact thereof on HT use (Freeman, 2017; Johnson, 2017; Orji et al., 2020).

- Children using BCHDs is a population considered to be neglected in the field of paediatric amplification (Gordey & Bagatto, 2020). Data from this study suggested that children with chronic middle ear disease using BCHDs on a soft band are at particular risk for limited HT use (n = 18, 4.8 hours a day M, 2 SD, 1.2-7.8 range). Further investigation, particularly into using a soft band or adhesive BCHDs, is relevant, considering the high incidence of children with chronic otorrhea in LMICs (Kuschke et al., 2020; Samy et al., 2018) and the cost and fragility of these devices.

4.5 Conclusion

While HT use is a multi-factorial outcome measure, this study identified an extensive range of predictive factors that could predict and increase HT use in children with hearing loss. Intrinsic

predictors of increased HT use in children included older chronological age, more severe hearing loss, and older ages at diagnosis and initial HA fitting. Extrinsic predictors of increased HT use identified included the child's ability to independently use HT, at least one CI as part of the HT fitting, coordinated onsite audiological management, self-procured batteries, auditory-oral communication mode, and regular caregiver intervention attendance. Though factors like the degree of hearing loss and chronological age cannot be manipulated or modified, identifying, and manipulating malleable predictors of HT use, such as caregiver intervention attendance and independent HT use, could positively influence children's developmental outcomes. This study identified six newly described predictor factors of HT use a diverse, unselected sample of children with hearing loss. Knowledge of these potential barriers and enablers of HT use in children can guide audiologists in delivering evidence-based paediatric hearing healthcare services.

"I will not allow yesterday's success to lull me into today's complacency, for this will be the foundation of failure for tomorrow" (Mandino, 2011, p. 55)***.***

5. REFERENCES

Abbott, K. V., Barton, F. B., Terhorst, L., & Shembel, A. (2016). Retrospective studies: A fresh look. *American Journal of Speech-Language Pathology*, *25*(2), 1–7. https://doi.org/10.1044/2016_AJSLP-16-0025

Adadey, S. M., Awandare, G., Amedofu, G. K., & Wonkam, A. (2017). Public health burden of hearing impairment and the promise of genomics and environmental research: A case study in Ghana, Africa. *OMICS A Journal of Integrative Biology*, *21*(11), 633–637. https://doi.org/10.1089/omi.2017.0145

Adedeji, T. O., Tobih, J. E., Sogebi, O. A., & Daniel, A. D. (2015). Management challenges of congenital & early onset childhood hearing loss in a sub-Saharan African country. *International Journal of Pediatric Otorhinolaryngology*, *79*(10), 1625–1629. https://doi.org/10.1016/j.ijporl.2015.06.003

Adegbiji, W. A., Olajide, G. T., Olatoke, F., Olajuyin, A. O., Aremu, S. K., Ali, A., & Eletta, P. A. (2018). Preschool children with hearing impairment: Prevalence, diagnosis and management in a developing country. *International Tinnitus Journal*, *22*(1), 60–65. https://doi.org/10.5935/0946-5448.20180010

Ahmed, S., Hajabubker, M. A., & Satti, S. A. (2017). Risk factors and management modalities for Sudanese children with hearing loss or hearing impairment done in Aldwha and Khartoum ENT hospitals, Sudan. *Annals of Tropical Medicine and Public Health*, *10*(2), 357–361. https://doi.org/10.4103/1755-6783.208721

Alduhaim, A., Purcell, A., Cumming, S., & Doble, M. (2020). Parents' views about factors facilitating their involvement in the oral early intervention services provided for their children with hearing loss in Kuwait. *International Journal of Pediatric Otorhinolaryngology*, *128*, 109717–109717. https://doi.org/10.1016/j.ijporl.2019.109717

Alduhaim, A., Purcell, A., Cumming, S., & Doble, M. (2021). A new training package (3Cs: Connect, Communicate and Collaborate) for improving family responsive service delivery in early intervention for children with hearing loss: A proof of concept study. *International Journal of Pediatric Otorhinolaryngology*, *140*, 110484. https://doi.org/10.1016/j.ijporl.2020.110484

Ambrose, S. E., Appenzeller, M., Al-Salim, S., & Kaiser, A. P. (2020). Effects of an intervention designed to increase toddlers' hearing aid use. *Journal of Deaf Studies and Deaf Education*, *25*(1), 55–67. https://doi.org/10.1093/deafed/enz032

American Academy of Audiology. (2013). *American Academy of Audiology: Clinical practice guidelines: Pediatric amplification*. https://www.audiology.org/sites/default/files/publications/PediatricAmplificationGuidelines.pdf

American Speech-Language-Hearing Association. (2008). *Guidelines for audiologists providing informational and adjustment counseling to families of infants and young children with hearing loss birth to 5 years of age*. http://www.asha.org/docs/pdf/GL2008-00289.pdf

Anderson, K., & Madell, J. (2013). *Hearing device retention accessory information*. http://www.getsafensound.com/

Appenzeller, M. C., & Ambrose, S. E. (2020). Using technology to monitor hearing device use and linguistic environments: early intervention providers' perspectives. *Journal of Early Hearing Detection and Intervention*, *5*(1), 62–72. https://doi.org/10.26077/xfzs-4831

Archbold, S. M., Nikolopoulous, T. P., & Lloyg-Richmond, H. (2009). Long-term use of cochlear implant systems in pediatric recipients and factors contributing to non-use. *Cochlear Implants International*, *10*(1), 25–40. https://doi.org/10.1002/cii.363

Asoegwu, C. N., Ogban, L. U., & Nwawolo, C. C. (2019). A preliminary report of the audiological profile of hearing impaired pupils in inclusive schools in Lagos state, Nigeria. *Disability, CBR and Inclusive Development*, *30*(2), 95–103. https://doi.org/10.5463/dcid.v30i2.821

Athalye, S., Archbold, S., Mulla, I., Lutman, M., & Nikolopoulous, T. (2015). Exploring views on current and future cochlear implant service delivery: The perspectives of users, parents and professionals at cochlear implant centres and in the community. *Cochlear Implants International*, *16*(5), 241–253. https://doi.org/10.1179/1754762815Y.0000000003

Babbie, E. R. (2010). *The practice of social research* (8th ed.). Wadsworth Publishing Company. https://doi.org/9780495598411

Bagatto, M. (2016). Considerations for hearing aid use in infants and children who have mild bilateral hearing loss. *Perspectives of the ASHA Special Interest Groups*, *1*(6), 17. https://doi.org/10.1044/persp1.SIG6.17

Bagatto, M., DesGeorges, J., King, A., Kitterick, P., Laurnagaray, D., Lewis, D., Roush, P., Sladen, D. P., & Tharpe, A. M. (2019). Consensus practice parameter: audiological assessment and management of unilateral hearing loss in children. *International Journal of Audiology*, *58*(2), 1–11. https://doi.org/10.1080/14992027.2019.1654620

Bagatto, M., Moodie, S., Brown, C., Malandrino, A., Richert, F., Clench, D., & Scollie, S. (2016). Prescribing and verifying hearing aids applying the American Academy of Audiology pediatric amplification guideline: protocols and outcomes from the Ontario infant hearing program. *Journal of the American Academy of Audiology*, *27*(3), 188–203. https://doi.org/10.3766/jaaa.15051

Barchard, K. A., & Pace, L. A. (2011). Preventing human error: The impact of data entry methods on data accuracy and statistical results. *Computers in Human Behavior*, *27*(5), 1834–1839. https://doi.org/10.1016/j.chb.2011.04.004

Bennett, R. J., Zhang, M., Mulders, W. H. A. M., Stegeman, I., Vagg, B., Brennan-Jones, C. G., & Eikelboom, R. H. (2020). Hearing aid review appointments: Clients' reasons for attendance and non-attendance. *International Journal of Audiology*, *59*(2), 101–108. https://doi.org/10.1080/14992027.2019.1663373

Bess, F. H., Davis, H., Camarata, S., & Hornsby, B. (2020). Listening-related fatigue in children with unilateral hearing loss. *Language, Speech, and Hearing Services in Schools*, *51*(1), 84–97. https://doi.org/10.1044/2019_LSHSS-OCHL-19-0017

Blaiser, K. M., & Thompson, N. (2019). Data-logging is a friend to children's hearing health. *The ASHA Leader*, *24*(10), 22–23. https://doi.org/10.1044/leader.AEA.24102019.22

Boisvert, I., Clemesha, J., Lundmark, E., Crome, E., Barr, C., & McMahon, C. M. (2017). Decision-making in audiology: Balancing evidence-based practice and patient-centered care. *Trends in Hearing*, *21*, 1–14. https://doi.org/10.1177/2331216517706397

Bolat, H., Bebitoglu, F. G., Ozbas, S., Altunsu, A. T., & Kose, M. R. (2009). National newborn hearing screening program in Turkey: Struggles and implementations between 2004 and 2008. *International Journal of Pediatric Otorhinolaryngology*, *73*(12), 1621–1623. https://doi.org/10.1016/j.ijporl.2009.08.002

Booysen, S., Bester, J., & Laubscher, R. (2014a). Factors influencing auditory-based communication outcomes in South African children with hearing loss [Conference presentation]. In *Hearing Across the Lifespan Conference, 5-7 June 2014, Cernobbio - Lake Como, Italy*.

Booysen, S., Bester, J., & Laubscher, R. (2014b). Hearing aid use and rate of progress in children with mild to profound hearing loss: A South African experience [Conference presentation]. *The 2nd Family Centred Early Intervention Conference, 11-13 April 2014, Bad Ischl, Austria*.

Booysen, S., & Eksteen, S. (2017). Trends in identification and intervention: Snapshot of the Carel du

Toit population [Conference presentation]. *The 4th Ndiyeva Paediatric Audiology and Intervention Conference, 30-31 March 2017, Somerset-West, South Africa*.

Bouwmeester, W., Zuithoff, N. P. A., Mallett, S., Geerlings, M. I., Vergouwe, Y., Steyerberg, E. W., Altman, D. G., & Moons, K. G. M. (2012). Reporting and methods in clinical prediction research: A systematic review. *PLoS Medicine*, *9*(5), Article e1001221. https://doi.org/10.1371/journal.pmed.1001221

Brough, H., & Kachaje, T. (2020). Follow-up care for pediatric hearing aid users at an audiology clinic in Malawi. *Perspectives of the ASHA Special Interest Groups*, *5*(6), 1809–1812. https://doi.org/10.1044/2020_persp-20-00129

Bruijnzeel, H., Bezdjian, A., Lesinski-Schiedat, A., Illg, A., Tzifa, K., Monteiro, L., Volpe, A. D., Grolman, W., & Topsakal, V. (2017). Evaluation of timely pediatric cochlear implant care throughout Europe: Is European cochlear implantation care according to guidelines? *Cochlear Implants International*, *18*(6), 1–10. https://doi.org/10.1080/14670100.2017.1375238

Buchman, C. A., Gifford, R. H., Haynes, D. S., Lenarz, T., O'Donoghue, G., Adunka, O., Biever, A., Briggs, R., Carlson, M. L., Dai, P., Driscoll, C., Francis, H., Gantz, B., Gurgel, R. K., Hansen, M. R., Holcomb, M., Karltorp, E., Kirtane, M., Larky, J., … Zwolan, T. (2020). Unilateral cochlear implants for severe, profound, or moderate sloping to profound bilateral sensorineural hearing loss. A systematic review. *JAMA Otolaryngology–Head & Neck Surgery*, *146*(10), 942-953. https://doi.org/10.1001/jamaoto.2020.0998

Busch, T., Vanpoucke, F., & van Wieringen, A. (2017). Auditory environment across the life span of cochlear implant users: Insights from data logging. *Journal of Speech, Language, and Hearing Research*, *60*(5), 1362–1377. https://doi.org/10.1044/2016_JSLHR-H-16-0162

Busch, T., Vermeulen, A., Langereis, M., Vanpoucke, F., & Van Wieringen, A. (2019). Cochlear implant data logs predict children's receptive vocabulary. *Ear & Hearing*, *41*(4), 733–746. https://doi.org/10.1097/AUD.0000000000000818

Bush, M. L., Hardin, B., Rayle, C., Lester, C., Studts, C. R., & Shinn, J. B. (2014). Rural barriers to early diagnosis and treatment of infant hearing loss in Appalachia. *Otology & Neurotology*, *36*(1), 93–98. https://doi.org/10.1097/MAO.0000000000000636

Bush, M. L., Kaufman, M. R., & McNulty, B. N. (2017). Disparities in access to pediatric hearing health care. *Current Opinion in Otolaryngology and Head and Neck Surgery*, *25*(5), 359–364. https://doi.org/10.1097/MOO.0000000000000388

Carel du Toit Centre and Trust. (2021). *Carel du Toit Centre and Trust Annual Report 2019-2020*.

Carr, T., & Lord, C. (2016). A pilot study promoting participation of families with limited resources in early autism intervention. *Research in Autism Spectrum Disorders*, *25*, 87–96. https://doi.org/10.1016/j.rasd.2016.02.003

Carr, T., Shih, W., Lawton, K., Lord, C., King, B., & Kasari, C. (2016). The relationship between treatment attendance, adherence, and outcome in a caregiver-mediated intervention for low-resourced families of young children with autism spectrum disorder. *Autism*, *20*(6), 643–652. https://doi.org/10.1177/1362361315598634

Carruthers, J. (2019). Academic integrity. *South African Journal of Science*, *115*(11–12), Article e7439. https://doi.org/10.17159/sajs.2019/7439

Cesur, S., Yüksel, M., & Çiprut, A. (2020). Data logging variables and speech perception in prelingually deafened pediatric cochlear implant users. *International Journal of Pediatric Otorhinolaryngology*, *133*, Article e110003. https://doi.org/10.1016/j.ijporl.2020.110003

Chabon, S., Morris, J., & Lemoncello, R. (2011). Ethical deliberation: A foundation for evidence-based practice. *Seminars in Speech and Language*, *32*(4), 298–308. https://doi.org/10.1055/s-0031-1292755

Ching, T. Y. C., Dillon, H., Leigh, G., & Cupples, L. (2018). Summary of LOCHI findings at 5 years. *International Journal of Audiology*, *57*(S2), S105–S111. https://doi.org/doi:10.1080/14992027.2017.1385865

Ching, T. Y. C., Dillon, H., Leigh, G., Cupples, L., Nelson, L. H., Herde, L., Muñoz, K., White, K. R., Page, M. D., Theunissen, M., Swanepoel, D. W., Hickson, L., Meyer, C., Lovelock, K., Lampert, M., Khan, A., Watermeyer, J., Kanji, A., Cohen, A., … Moore, E. (2018). Learning from the longitudinal outcomes of children with hearing impairment (LOCHI) study: Summary of 5-year findings and implications. *International Journal of Audiology*, *57*(S2), S105–S111. https://doi.org/10.1080/14992027.2017.1385865

Ching, T. Y. C., & Hill, M. (2007). The Parents' Evaluation of Aural/Oral Performance of Children (PEACH) scale: Normative data. *Journal of American Academy of Audiology*, *18*(3), 220–235. https://doi.org/doi.org/10.3766/jaaa.18.3.4

Chowdhury, M. Z. I., & Turin, T. C. (2020). Variable selection strategies and its importance in clinical prediction modelling. *Family Medicine and Community Health*, *8*(1), Article e000262. https://doi.org/10.1136/fmch-2019-000262

Clark, J. G. (1981). Uses and abuses of hearing loss classification. *Asha*, *23*(7), 493–500. https://www.researchgate.net/publication/16145943 Uses

Cupples, L., Ching, T. Y. C., Button, L., Seeto, M., Zhang, V., Whitfield, J., Gunnourie, M., Martin, L., & Marnane, V. (2018). Spoken language and everyday functioning in 5-year-old children using hearing aids or cochlear implants. *International Journal of Audiology*, *57*(S2), S55–S69. https://doi.org/10.1080/14992027.2017.1370140

Davids, R., Roman, N., & Schenck, C. (2021). The challenges experienced by parents when parenting a child with hearing loss within a South African context. *Journal of Family Social Work*, 1–18. https://doi.org/10.1080/10522158.2020.1852639

Davis, A., & Hoffman, H. J. (2019). Hearing loss: Rising prevalence and impact. *Bulletin of the World Health Organization*, *97*(10), 646-646A. https://doi.org/10.2471/BLT.19.224683

De Jong, T., van der Schroeff, M., & Vroegop, J. (2021). Child- and environment-related factors influencing daily cochlear implant use. *Ear & Hearing*, *42*(1), 122–129. https://doi.org/10.1097/aud.0000000000000911

Department of Health Republic of South Africa. (2015). *Ethics in health research: Principles, processes, and structures.* (2nd ed., pp. 1–94). https://doi.org/10.5377/encuentro.v42i86.66

Desalew, A., Feto Gelano, T., Semahegn, A., Geda, B., & Ali, T. (2020). Childhood hearing impairment and its associated factors in sub-Saharan Africa in the 21st century: A systematic review and meta-analysis. *SAGE Open Medicine*, *8*, 1–11. https://doi.org/10.1177/2050312120919240

Dillard, L. K., Saunders, G. H., Zobay, O., & Naylor, G. (2020). Insights into conducting audiological research with clinical databases. *American Journal of Audiology*, *29*(3), 676–681. https://doi.org/10.1044/2020_AJA-19-00067

Dillon, H., Cowan, R., & Ching, T. Y. C. (2013). Longitudinal outcomes of children with hearing impairment (LOCHI). *International Journal of Audiology*, *52*(S2), S2–S3. https://doi.org/10.3109/14992027.2013.866448

Du Toit, C. J. (1975). The organisation of comprehensive audiological services in the Cape province. *South African Medical Journal*, *49*(14), 599–604. https://journals.co.za/doi/pdf/10.10520/AJA20785135_23803

Dunteman, G., & Ho., M.-H. (2006). *An introduction to generalized linear models*. SAGE Publications, Inc. https://doi.org/10.4135/9781412983273

Easwar, V., Sanfilippo, J., Papsin, B., & Gordon, K. A. (2016). Factors affecting daily cochlear implant use in children: Datalogging evidence. *Journal of the American Academy of Audiology*, *27*(10), 824–838. https://doi.org/10.3766/jaaa.15138

Easwar, V., Sanfilippo, J., Papsin, B., & Gordon, K. A. (2018). Impact of consistency in daily device use on speech perception abilities in children with cochlear implants: Datalogging evidence. *Journal of the American Academy of Audiology*, *29*(9), 835–846. https://doi.org/10.3766/jaaa.17051

Ekberg, K., Meyer, C., Hickson, L., & Scarinci, N. (2020). Parents' questions to clinicians within paediatric hearing habilitation appointments for children with hearing impairment. *Patient Education and Counseling*, *103*(3), 491–499. https://doi.org/10.1016/j.pec.2019.09.015

Emmett, S., Tucci, D. L., Bento, R. F., Garcia, J. M., Juman, S., Chiossone-Kerdel, J. A., Liu, T. J., De Muñoz, P. C., Ullauri, A., Letort, J. J., Mansilla, T., Urquijo, D. P., Aparicio, M. L., Gong, W., Francis, H. W., & Saunders, J. E. (2016). Moving beyond GDP: Cost effectiveness of cochlear implantation and Deaf education in Latin America. *Otology and Neurotology*, *37*(8), 1040–1048. https://doi.org/10.1097/MAO.0000000000001148

English, K., Walker, E., Farah, K., Munoz, K., Pelosi, A., Scarinci, N., DesGeorges, J., Aungst, H., Madell, J., Moeller, M. P., Marriage, J., Flexer, C., & Jones, C. (2017). Implementing family-centered care in early intervention for children with hearing loss: Engaging parents with a Question Prompt List (QPL). *Hearing Review.*, *24*(11), 12–18. https://advancingaudcounseling.com/wp-content/uploads/2019/01/Englishetal_FCC_QPL_1117HR.pdf

Erbasi, E., Hickson, L., & Scarinci, N. (2017). Communication outcomes of children with hearing loss enrolled in programs implementing different educational approaches: A systematic review. *Speech, Language and Hearing*, *20*(2), 102–121. https://doi.org/10.1080/2050571X.2016.1238611

Erbasi, E., Scarinci, N., Hickson, L., & Ching, T. Y. C. (2018). Parental involvement in the care and intervention of children with hearing loss. *International Journal of Audiology*, *57*(S2), S15–S26. https://doi.org/10.1080/14992027.2016.1220679

Etikan, I., Abubakar Musa, S., & Sunusi Alkassim, R. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, *5*(1), 1–4. https://doi.org/10.11648/j.ajtas.20160501.11

Fagan, J., & Tarabichi, M. (2018). Cochlear implants in developing countries: Practical and ethical considerations. *Current Opinion in Otolaryngology and Head and Neck Surgery*, *26*(3), 188–189.

https://doi.org/10.1097/MOO.0000000000000457

Faraway, J. (2016). *Extending the linear model with R: Generalized linear, mixed effects and nonparametric regression models*. Taylor & Francis Group, LLC. https://doi.org/10.1111/j.1541-0420.2006.00596_12.x

Fitzpatrick, E., Cologrosso, E., & Sikora, L. (2019). Candidacy for amplification in children with hearing loss: A review of guidelines and recommendations. *American Journal of Audiology*, *28*(4), 1025–1045. https://doi.org/10.1044/2019_AJA-19-0061

Fitzpatrick, E., Coyle, D., Gaboury, I., Durieux-Smith, A., Whittingham, J. A., Grandpierre, V., Na, E., & Salamatmanesh, M. (2019). Service preferences of parents of children with mild bilateral or unilateral hearing loss: A conjoint analysis study. *Ear & Hearing*, *40*(3), 671–679. https://doi.org/10.1097/AUD.0000000000000651

Fitzpatrick, E., Hamel, C., Stevens, A., Pratt, M., Moher, D., Doucet, S. P., Neuss, D., Bernstein, A., & Na, E. (2016). Sign language and spoken language for children with hearing loss: A systematic review. *Pediatrics*, *137*(1), Article e20151974. https://doi.org/10.1542/peds.2015-1974

Fitzpatrick, E., Stevens, A., Garrity, C., & Moher, D. (2013). A systematic review of the effects of using sign language on spoken language acquisition in children with early-identified hearing loss. *Systematic Reviews*, *2*(108), 1–7. https://doi.org/10.1016/j.jclinepi.2010.07.015

Flexer, C., & Cole, E. (2020). Learning to listen: Audiologists are pivotal. *Audiol. Today*, *32*(1), 14–22. https://www.audiology.org/audiology-today-januaryfebruary-2020/learning-listen-audiologists-are-pivotal

Flexer, C., & Wolfe, J. (2020). Auditory brain development and auditory verbal therapy. In W. Estabrooks, H. M. Morrison, & K. MacIver-Lux (Eds.), *Auditory-verbal Therapy: Science, research, and practice* (pp. 35–58). Plural Publishing, Inc.

Fobi, D., & Oppong, A. M. (2019). Communication approaches for educating deaf and hard of hearing (DHH) children in Ghana: historical and contemporary issues. *Deafness and Education International*, *21*(4), 195–209. https://doi.org/10.1080/14643154.2018.1481594

Freeman, B. (2017). The changing landscape of hearing aid batteries. *The Hearing Review*, *24*(11), 34–36. https://www.hearingreview.com/inside-hearing/research/changing-landscape-hearing-aid-batteries-2

Fulcher, A., Purcell, A. A., Baker, E., & Munro, N. (2012). Listen up: Children with early identified hearing loss achieve age-appropriate speech/language outcomes by 3 years-of-age.

International Journal of Pediatric Otorhinolaryngology, *76*(12), 1785–1794. https://doi.org/10.1016/j.ijporl.2012.09.001

Fulcher, A., Purcell, A., Baker, E., & Munro, N. (2015). Factors influencing speech and language outcomes of children with early identified severe/profound hearing loss: Clinician-identified facilitators and barriers. *International Journal of Speech-Language Pathology*, *17*(3), 325–333. https://doi.org/10.3109/17549507.2015.1032351

Gaeta, L., & Brydges, C. R. (2020). An examination of effect sizes and statistical power in speech, language, and hearing research. *Journal of Speech, Language, and Hearing Research*, *63*(5), 1572–1580. https://doi.org/10.1044/2020_JSLHR-19-00299

Gagnon, E., Eskridge, H., & Brown, K. (2020). Pediatric cochlear implant wear time and early language development. *Cochlear Implants International*, *21*(2), 92–97. https://doi.org/10.1080/14670100.2019.1670487

Gagnon, E., Eskridge, H., Brown, K. D., & Park, L. R. (2021). The impact of cumulative cochlear implant wear time on spoken language outcomes at age 3 years. *Journal of Speech, Language, and Hearing Research*, Article e1092-4388. https://doi.org/10.1044/2020_JSLHR-20-00567

Galland, B. C., Taylor, B. J., Elder, D. E., & Herbison, P. (2012). Normal sleep patterns in infants and children: A systematic review of observational studies. *Sleep Medicine Reviews*, *16*(3), 213–222. https://doi.org/10.1016/j.smrv.2011.06.001

Ganek, H. V., Cushing, S. L., Papsin, B. C., & Gordon, K. A. (2020). Cochlear implant use remains consistent over time in children with single-sided deafness. *Ear & Hearing*, *41*(3), 678–685. https://doi.org/10.1097/AUD.0000000000000797

Gearing, R. E., Mian, I. A., Barber, J., & Ickowicz, A. (2006). A methodology for conducting retrospective chart review research in child and adolescent psychiatry. *Journal of the Canadian Academy of Child and Adolescent Psychiatry*, *15*(3), 126–134. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2277255/pdf/ccap15_3p126.pdf

Glista, D., O'Hagan, R., Van Eeckhoutte, M., Lai, Y., & Scollie, S. (2021). The use of ecological momentary assessment to evaluate real-world aided outcomes with children. *International Journal of Audiology*, Advanced online publication. https://doi.org/10.1080/14992027.2021.1881629

Gordey, D., & Bagatto, M. (2020). Fitting bone conduction hearing devices to children: audiological practices and challenges. *International Journal of Audiology*, 1–8.

https://doi.org/10.1080/14992027.2020.1814970

Gordon, K. A., Papsin, B. C., & Harrison, R. V. (2003). Activity-dependent developmental plasticity of the auditory brain stem in children who use cochlear implants. *Ear & Hearing*, *24*(6), 485–500. https://doi.org/10.1097/01.AUD.0000100203.65990.D4

Govender, S. M., & Mars, M. (2017). The use of telehealth services to facilitate audiological management for children: A scoping review and content analysis. *Journal of Telemedicine and Telecare*, *23*(3), 392–401. https://doi.org/10.1177/1357633X16645728

Gregory, K. E., & Radovinsky, L. (2012). Research strategies that result in optimal data collection from the patient medical record. *Appl Nursing Research*, *25*(2), 108–116. https://doi.org/10.1016/j.apnr.2010.02.004

Guerzoni, L., & Cuda, D. (2017). Speech processor data logging helps in predicting early linguistic outcomes in implanted children. *International Journal of Pediatric Otorhinolaryngology*, *101*, 81–86. https://doi.org/10.1016/j.ijporl.2017.07.026

Gustafson, S. J., Davis, H., Hornsby, B., & Bess, F. H. (2015). Factors influencing hearing aid use in the classroom: A pilot study. *American Journal of Audiology*, *24*(4), 563–568. https://doi.org/10.1044/2015_AJA-15-0024

Gustafson, S. J., Ricketts, T. A., & Tharpe, A. M. (2017). Hearing technology use and management in school-age children: Reports from data logs, parents, and teachers. *Journal of the American Academy of Audiology*, *28*(10), 883–892. https://doi.org/10.3766/jaaa.16042

Hall, M. L. (2020). The input matters: Assessing cumulative language access in deaf and hard of hearing individuals and populations. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.01407

Hall, W. C. (2017). What you don't know can hurt you: The risk of language deprivation by impairing sign language development in deaf children. *Maternal and Child Health Journal*, *21*(5), 961–965. https://doi.org/10.1007/s10995-017-2287-y

Hall, W. C., Levin, L. L., & Anderson, M. L. (2017). Language deprivation syndrome: A possible neurodevelopmental disorder with sociocultural origins. *Social Psychiatry and Psychiatric Epidemiology*, *52*(6), 761–776. https://doi.org/10.1007/s00127-017-1351-7

Hanass-Hancock, J., Nene, S., Deghaye, N., & Pillay, S. (2017). "These are not luxuries, it is essential for access to life": Disability related out-of-pocket costs as a driver of economic vulnerability in South Africa. *African Journal of Disability*, *6*(0), Article a280. https://doi.org/10.4102/ajod

Harrison, M., Page, T. A., Oleson, J., Spratford, M., Berry, L. U., Peterson, B., Welhaven, A., Arenas, R. M., Moeller, M. P., Unflat Berry, L., Peterson, B., Welhaven, A., Arenas, R. M., & Moeller, M. P. (2016). Factors affecting early services for children who are hard of hearing. *Language Speech and Hearing Services in Schools*, *47*(1), 16. https://doi.org/10.1044/2015_LSHSS-14-0078

Havenga, E., Swanepoel, D. W., le Roux, T., & Schmid, B. (2017). Tele-intervention for children with hearing loss: A comparative pilot study. *Journal of Telemedicine and Telecare*, *23*(1), 116–125. https://doi.org/10.1177/1357633X15617886

Hawley, K. A., Goldberg, D. M., & Anne, S. (2017). Utility of a multidisciplinary approach to pediatric hearing loss. *American Journal of Otolaryngology*, *38*(5), 547–550. https://doi.org/10.1016/j.amjoto.2017.05.008

Health Professions Council of South Africa. (2008). *General ethical guidelines for health researchers: Booklet 6*. http://www.hpcsa.co.za/Uploads/editor/UserFiles/downloads/conduct_ethics/rules/generic_ethical_rules/booklet_6_gen_ethical_guidelines_for_researchers.pdf

Health Professions Council of South Africa. (2018). *Early hearing detection and intervention (EHDI) programmes in South Africa: 2018 Position statement*. http://www.hpcsa.co.za/Uploads/editor/UserFiles/downloads/speech/Guidelines_for_EHDI_2018.pdf

Hintermair, M., Cremer, I., Gutjahr, A., Losch, A., & Strauß, H. C. (2018). Factors for professional success–what deaf education can learn from deaf and hard of hearing people who are successful in their career. *Volta Review*, *117*(1–2), 32–61. https://doi.org/10.17955/tvr.117.1.2.794

Hoffman, M. F., Cejas, I., & Quittner, A. L. (2019). Health-related quality of life instruments for children with cochlear implants: Development of child and parent-proxy measures. *Ear & Hearing*, *40*(3), 592–604. https://doi.org/10.1097/AUD.0000000000000631

Holzinger, D., Fellinger, J., & Beitel, C. (2011). Early onset of family centred intervention predicts language outcomes in children with hearing loss. *International Journal of Pediatric Otorhinolaryngology*, *75*(2), 256–260. https://doi.org/10.1016/j.ijporl.2010.11.011

Humes, L. E. (2019). The World Health Organization's hearing-impairment grading system: An evaluation for unaided communication in age-related hearing loss. *International Journal of Audiology*, *58*(1), 12–20. https://doi.org/10.1080/14992027.2018.1518598

Jilla, A. M., Johnson, C. E., Danhauer, J. L., Anderson, M., Smith, J. N., Sullivan, J. C., & Sanchez, K. R. (2019). Predictors of Hearing Aid Use in the Advanced Digital Era: An Investigation of Benefit, Satisfaction, and Self-Efficacy. *Journal of the American Academy of Audiology*. https://doi.org/10.3766/jaaa18036

Johnson, J. (2017). Hearing aid batteries: Know your options. *Hearing Journal*, *71*(1), 44. https://doi.org/10.1097/01.HJ.0000529851.08871.44

Joint Committee on Infant Hearing. (2019). Year 2019 position statement: Principles and guidelines for early hearing detection and intervention programs. *The Journal of Early Hearing Detection and Intervention*, *4*(2), 1–44. https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1104&context=jehdi

Jones, C., & Launer, S. (2010). Pediatric fittings in 2010: The Sound Foundation Cuper project. In R. Seewald & J. Bamford (Eds.), *Sound foundation through early amplification: Proceedings of the 2010 international conference.* (pp. 187–192). http://www.phonakpro.com/content/dam/phonak/gc_hq/b2b/en/events/2010/Proceedings/Pho_Chap_12_Jones_Final.pdf

Joubert, K., & Githinji, E. (2014). Quality and readability of information pamphlets on hearing and paediatric hearing loss in the Gauteng Province, South Africa. *International Journal of Pediatric Otorhinolaryngology*, *78*(2), 354–358. https://doi.org/10.1016/j.ijporl.2013.12.018

Juluru, K., & Eng, J. (2015). Use of spreadsheets for research data collection and preparation: A primer. *Academic Radiology*, *22*(12), 1592–1599. https://doi.org/10.1016/j.acra.2015.08.024

Kaji, A. H., Schriger, D., & Green, S. (2014). Looking through the retrospectoscope: Reducing bias in emergency medicine chart review studies. *Annals of Emergency Medicine*, *64*(3), 292–298. https://doi.org/10.1016/j.annemergmed.2014.03.025

Kanji, A. (2018). Early hearing detection and intervention: Reflections from the South African context. *South African Journal of Communication Disorders*, *65*(1), 581. https://doi.org/10.4102/sajcd.v65i1.581

Kanji, A. (2021). Models of care in early intervention for children with hearing impairment. In K. Khoza-Shangase & A. Kanji (Eds.), *Early Detection and Intervention in Audiology: An African Perspective* (pp. 137–154). Wits University Press.

Kara, N., & Harvey, C. (2017). The social construction of “deafness”: Explored through the experiences of Black South African mothers raising a deaf child. *South African Journal of*

Psychology, *47*(1), 72–83. https://doi.org/10.1177/0081246316648517

Kemaloğlu, Y. K., Gökdoğan, Ç., Gündüz, B., Önal, E. E., Türkyılmaz, C., & Atalay, Y. (2016). Newborn hearing screening outcomes during the first decade of the program in a reference hospital from Turkey. *European Archives of Oto-Rhino-Laryngology*, *273*(5), 1143–1149. https://doi.org/10.1007/s00405-015-3654-1

Khoza-Shangase, K. (2019). Early hearing detection and intervention in South Africa: Exploring factors compromising service delivery as expressed by caregivers. *International Journal of Pediatric Otorhinolaryngology*, *118*, 73–78. https://doi.org/10.1016/j.ijporl.2018.12.021

Khoza-Shangase, K., & Kanji, A. (Eds.). (2021). *Early detection and intervention in Audiology: An African perspective*. Wits University Press.

Kivimäki, M., Batty, G. D., Pentti, J., Shipley, M. J., Sipilä, P. N., Nyberg, S. T., Suominen, S. B., Oksanen, T., Stenholm, S., Virtanen, M., Marmot, M. G., Singh-Manoux, A., Brunner, E. J., Lindbohm, J. V., Ferrie, J. E., & Vahtera, J. (2020). Association between socioeconomic status and the development of mental and physical health conditions in adulthood: A multi-cohort study. *The Lancet Public Health*, *5*(3), e140–e149. https://doi.org/10.1016/S2468-2667(19)30248-8

Klein, K. E., Spratford, M., Redfern, A., & Walker, E. A. (2019). Effects of grade and school services on children's responsibility for hearing aid care. *American Journal of Audiology*, *28*(3), 673–685. https://doi.org/10.1044/2019_AJA-19-0005

Kleinert, J. O., Harrison, E. M., Fisher, T. L., & Kleinert, H. L. (2010). "I can" and "I did"—Self-advocacy for young students with developmental disabilities. *Teaching Exceptional Children*, *43*(2), 16–26. https://doi.org/10.1177/004005991004300202

Kral, A., Kronenberger, W. G., Pisoni, D. B., & O'Donoghue, G. M. (2016). Neurocognitive factors in sensory restoration of early deafness: A connectome model. *The Lancet Neurology*, *15*(6), 610–621. https://doi.org/10.1016/S1474-4422(16)00034-X

Kral, A., & Lenarz, T. (2015). How the brain learns to listen: Deafness and the bionic ear. *E-Neuroforum*, *6*(1), 21–28. https://doi.org/10.1007/s13295-015-0004-0

Kral, A., & O'Donoghue, G. M. (2010). Profound deafness in childhood. *New England Journal of Medicine*, *363*(15), 1438–1450. https://doi.org/10.1056/NEJMra0911225

Krefting, L. (1991). Rigor in qualitative research: The assessment of trustworthiness. *The American Journal of Occupational Therapy*, *45*(3), 214–222. https://doi.org/10.5014/ajot.45.3.214

Kupzyk, K. A., & Cohen, M. Z. (2015). Data validation and other strategies for data entry. *Western Journal of Nursing Research*, *37*(4), 546–556. https://doi.org/10.1177/0193945914532550

Kuschke, S., Swanepoel, D. W., le Roux, T., & Strauss, S. (2020). Profile of childhood hearing loss in the Western Cape, South Africa. *International Journal of Pediatric Otorhinolaryngology*, *137*, Article e110248. https://doi.org/10.1016/j.ijporl.2020.110248

Kushalnagar, P., Mathur, G., Moreland, C. J., Napoli, D. J., Osterling, W., Padden, C., & Rathmann, C. (2010). Infants and children with hearing loss need early language access. *Journal of Clinical Ethics*, *21*(2), 143–154. https://doi.org/10.1016/j.surg.2006.10.010.Use

Laplante-Lévesque, A., Nielsen, C., Jensen, L. D., & Naylor, G. (2014). Patterns of hearing aid usage predict hearing aid use amount (data logged and self-reported) and overreport. *Journal of the American Academy of Audiology*, *25*(2), 187–198. https://doi.org/10.3766/jaaa.25.2.7

Lasisi, O. A., Ayodele, J. K., & Ijaduola, G. T. A. (2006). Challenges in management of childhood sensorineural hearing loss in sub-Saharan Africa, Nigeria. *International Journal of Pediatric Otorhinolaryngology*, *70*(4), 625–629. https://doi.org/10.1016/j.ijporl.2005.08.009

Leedy, P. D., & Ormrod, J. E. (2020). *Practical research: Planning and design.* (7th ed.). Pearson Education Limited.

Leigh, J. R., Dettman, S., & Dowell, R. (2016). Evidence-based guidelines for recommending cochlear implantation for young children: Audiological criteria and optimizing age at implantation. *International Journal of Audiology*, *55*(S2), S9–S18. https://doi.org/10.3109/14992027.2016.1157268

Lester, E. B., Dawson, J. D., Gantz, B., & Hansen, M. R. (2011). Barriers to the early cochlear implantation of deaf children. *Otology and Neurotology*, *32*(3), 406–412. https://doi.org/10.1097/MAO.0b013e3182040c22

Lever, K., Peng, J., Lundine, J. P., Caupp, S., Wheeler, K. K., Sribnick, E. A., & Xiang, H. (2019). Attending follow-up appointments after pediatric traumatic brain injury: Caregiver-perceived barriers and facilitators. *Journal of Head Trauma Rehabilitation*, *34*(2), E21–E34. https://doi.org/10.1097/HTR.0000000000000433

Löfkvist, U., Bäckström, K., Dahlby-Skoog, M., Gunnarsson, S., Persson, M., & Lohmander, A. (2020). Babbling and consonant production in children with hearing impairment who use hearing aids or cochlear implants: A pilot study. *Logopedics Phoniatrics Vocology*, *45*(4), 172–180. https://doi.org/10.1080/14015439.2019.1695929

Lutalo-Kiingi, S., & De Clerck, G. A. M. (2017). Perspectives on the sign language factor in sub-Saharan Africa: Challenges of sustainability. *American Annals of the Deaf*, *162*(1), 47–56. https://doi.org/10.1353/aad.2017.0015

Maluleke, N. P., Khoza-Shangase, K., & Kanji, A. (2021). An integrative review of current practice models and/or process of family-centered early intervention for children who are deaf or hard of hearing. *Family & Community Health*, *44*(1), 59–71. https://doi.org/10.1097/FCH.0000000000000276

Mandino, O. (2011). *The greatest salesman in the world*. Bantam.

Mann, C. J. (2003). Observational research methods. Research design II: Cohort, cross-sectional, and case-control studies. *Emergency Medicine Journal*, *20*(1), 54–60. https://doi.org/10.1136/emj.20.1.54

Marnane, V., & Ching, T. Y. C. (2015). Hearing aid and cochlear implant use in children with hearing loss at three years of age: Predictors of use and predictors of changes in use. *International Journal of Audiology*, *54*(8), 554–551. https://doi.org/10.3109/14992027.2015.1017660

McCarthy, M., Leigh, G., & Arthur-Kelly, M. (2019). Telepractice delivery of family-centred early intervention for children who are deaf or hard of hearing: A scoping review. *Journal of Telemedicine and Telecare*, *25*(4), 249–260. https://doi.org/10.1177/1357633X18755883

McCreery, R. W. (2013). Speech intelligibility index: No magic number, but a reasonable solution. *The Hearing Journal*, *66*(4), 8–10. https://doi.org/10.1097/01.HJ.0000429415.23420.97

McCreery, R. W., Bentler, R. A., & Roush, P. A. (2013). Characteristics of hearing aid fittings in infants and young children. *Ear & Hearing*, *34*(6), 701–710. https://doi.org/10.1097/AUD.0b013e31828f1033

McCreery, R. W., & Walker, E. A. (2017). *Pediatric Amplification. Enhancing auditory access*. Plural Publishing, Inc.

McCreery, R. W., Walker, E. A., & Spratford, M. (2015). Understanding limited use of amplification in infants and children who are hard of hearing. *Perspectives on Hearing and Hearing Disorders in Childhood*, *25*(1), 15–23. http://successforkidswithhearingloss.com/wp-content/uploads/2013/07/Understanding-Limited-Use-of-Amp-in-Infants-and-Children-who-are-HOH-Sig-9-Perspectives-4_15.pdf

McPherson, B. (2014). Hearing assistive technologies in developing countries: Background, achievements and challenges. *Disability and Rehabilitation: Assistive Technology*, *9*(5), 360–

364. https://doi.org/10.3109/17483107.2014.907365

Meibos, A., Muñoz, K., White, K., Preston, E., Pitt, C., & Twohig, M. (2016). Audiologist practices: Parent hearing aid education and support. *Journal of the American Academy of Audiology*, *27*(4), 324–332. https://doi.org/10.3766/jaaa.15007

Mertler, C. A. (2016). *Introduction to educational research*. SAGE Publications Inc. https://us.sagepub.com/sites/default/files/upm-binaries/70019_Mertler_Chapter_7.pdf

Merugumala, S. V., Pothula, V., & Cooper, M. (2017). Barriers to timely diagnosis and treatment for children with hearing impairment in a southern Indian city: A qualitative study of parents and clinic staff. *International Journal of Audiology*, *56*(10), 733–739. https://doi.org/10.1080/14992027.2017.1340678

Mitchell, L. (2016). *The reflections of young Deaf adults regarding the transition from school to higher education and employment within the Western Cape [Unpublished master's dissertation].* [University of the Witwatersrand, South Africa]. http://wiredspace.wits.ac.za/bitstream/handle/10539/22320/MA Audiology by dissertation - L. Mitchell.pdf?sequence=5&isAllowed=y

Moeller, M. P. (2000). Early intervention and language development in children who are deaf and hard of hearing. *Pediatrics*, *106*(3), e43–e43. https://doi.org/10.1542/peds.106.3.e43

Moeller, M. P., Carr, G., Seaver, L., Stredler-Brown, A., & Holzinger, D. (2013). Best practices in family-centered early intervention for children who are deaf or hard of hearing: An international consensus statement. *Journal of Deaf Studies and Deaf Education*, *18*(4), 429–445. https://doi.org/10.1093/deafed/ent034

Moeller, M. P., Hoover, B., Peterson, B., & Stelmachowicz, P. (2009). Consistency of hearing aid use in infants with early-identified hearing loss. *American Journal of Audiology*, *18*(1), 14–22. https://doi.org/10.1044/1059-0889(2008/08-0010)

Moeller, M. P., & McCreery, R. W. (2017). Children who are hard of hearing: Still forgotten? In *The ASHA Leader* (Vol. 22, Issue 6, pp. 16–17). https://doi.org/10.1044/leader.AEA.22062017.16

Moeller, M. P., & Tomblin, J. B. (2015a). An introduction to the outcomes of children with hearing loss study. *Ear & Hearing*, *36*(S1), 4S-13S. https://doi.org/10.1097/AUD.0000000000000210

Moeller, M. P., & Tomblin, J. B. (2015b). Epilogue: Conclusions and implications for research and practice. *Ear & Hearing*, *36*(S1), 92S-98S. https://doi.org/10.1097/AUD.0000000000000214

Moore, D. R., & Shannon, R. V. (2009). Beyond cochlear implants: Awakening the deafened brain. *Nature Neuroscience*, *12*(6), 686–691. https://doi.org/10.1038/nn.2326

Moore, J. K., & Linthicum, F. H. (2007). The human auditory system: A timeline of development. *International Journal of Audiology*, *46*(9), 460–478. https://doi.org/10.1080/14992020701383019

Mouton, J. (2001). *How to succeed in your master's and doctoral studies: A South African guide and resource book*. Van Schaik Publishers.

Mulwafu, W., Ensink, R., Kuper, H., & Fagan, J. (2017). Survey of ENT services in sub-Saharan Africa: Little progress between 2009 and 2015. *Global Health Action*, *10*(1), Article e1289736. https://doi.org/10.1080/16549716.2017.1289736

Muñoz, K., Blaiser, K., & Barwick, K. (2013). Parent hearing aid experiences in the United States. *Journal of the American Academy of Audiology*, *24*(1), 5–16. https://doi.org/10.3766/jaaa.24.1.2

Muñoz, K., Edelman, S. M., Ong, C. W., Aungst, H., Markle, K. L., & Twohig, M. P. (2020). Parent Perceptions of Person-Centered Care: A Randomized Controlled Trial of the Childhood Hearing Loss Question Prompt List for Parents. In *The Journal of Early Hearing Detection and Intervention* (Vol. 2020, Issue 2).

Muñoz, K., Kibbe, K., Preston, E., Caballero, A., Nelson, L., White, K., & Twohig, M. (2017). Paediatric hearing aid management: A demonstration project for using virtual visits to enhance parent support. *International Journal of Audiology*, *56*(2), 77–84. https://doi.org/10.1080/14992027.2016.1226521

Muñoz, K., Larsen, M., Nelson, L., Yoho, S., & Twohig, M. (2019). Pediatric amplification management: Parent experiences monitoring children's aided hearing. *Journal of Early Hearing Detection and Intervention*, *4*(1), 73–82. https://doi.org/10.26077/a049-v107

Muñoz, K., Nagaraj, N. K., & Nichols, N. (2020). Applied tele-audiology research in clinical practice during the past decade: A scoping review. *International Journal of Audiology*, 1–9. https://doi.org/10.1080/14992027.2020.1817994

Muñoz, K., Nelson, L., & Herald, K. (2018). Pediatric hearing device management: Professional practices for monitoring aided audibility. *Journal of Early Hearing Detection and Intervention*, *3*(1), 2–20. https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1075&context=jehdi

Muñoz, K., Olson, W. A., Twohig, M. P., Preston, E., Blaiser, K., & White, K. R. (2015). Pediatric

hearing aid use: Parent-reported challenges. *Ear & Hearing*, *36*(2), 279–287. https://doi.org/10.1097/AUD.0000000000000111

Muñoz, K., Preston, E., & Hicken, S. (2014). Pediatric hearing aid use: How can audiologists support parents to increase consistency? *Journal of the American Academy of Audiology*, *25*(4), 380–387. https://doi.org/10.3766/jaaa.25.4.9

Muñoz, K., Price, T., Nelson, L., & Twohig, M. (2019). Counseling in pediatric audiology: Audiologists' perceptions, confidence, and training. *Journal of the American Academy of Audiology*, *30*(1), 66–77. https://doi.org/10.3766/jaaa.17087

Muñoz, K., Rusk, S. E. P., Nelson, L., Preston, E., White, K. R., Barrett, T. S., & Twohig, M. P. (2016). Pediatric hearing aid management: Parent-reported needs for learning support. *Ear & Hearing*, *37*(6), 703–709. https://doi.org/10.1097/AUD.0000000000000338

Muñoz, K., San Miguel, G. G., Barrett, T. S., Kasin, C., Baughman, K., Reynolds, B., Ritter, C., Larsen, M., Whicker, J. J., & Twohig, M. P. (2021). eHealth parent education for hearing aid management: A pilot randomized controlled trial. *International Journal of Audiology*, 1–7. https://doi.org/10.1080/14992027.2021.1886354

Nelson, L. (2017). *Research in communication sciences and disorders: Methods for systematic inquiry* (3rd ed.). Plural Publishing, Inc. http://web.b.ebscohost.com.uplib.idm.oclc.org/ehost/ebookviewer/ebook/bmxlYmtfXzE3MjQ5OTdfX0FO0?sid=88228674-1c5b-4ff8-a9cb-05aa0631d696@sessionmgr101&vid=0&format=EB&rid=1

Nickbakht, M., Meyer, C., Scarinci, N., & Beswick, R. (2020). Exploring factors influencing the use of an eHealth intervention for families of children with hearing loss: An application of the COM-B model. *Disability and Health Journal*, *13*(4), Article e100921. https://doi.org/10.1016/j.dhjo.2020.100921

Ntamo, N. P., Buso, D., & Longo-Mbenza, B. (2013). Factors affecting poor attendance for outpatient physiotherapy by patients discharged from Mthatha General Hospital with a stroke. *South African Journal of Physiotherapy*, *69*(3), 19–24. https://doi.org/10.4102/sajp.v69i3.29

O'Donoghue, G. M., Tucci, D. L., & Wilson, B. S. (2017). The mounting burden of hearing loss worldwide: Gearing up global collaboration. *ENT and Audiology News*, *26*(5). https://doi.org/10.1016/S0140-6736(17)31073-5

Olusanya, B. O., Davis, A., & Hoffman, H. J. (2019). Hearing loss grades and the international

classification of functioning, disability and health. *Bulletin of the World Health Organization*, *97*(10), 725–728. https://doi.org/10.2471/BLT.19.230367

Orji, A., Kamenov, K., Dirac, M., Davis, A., Chadha, S., & Vos, T. (2020). Global and regional needs, unmet needs and access to hearing aids. *International Journal of Audiology*, *59*(3), 166–172. https://doi.org/10.1080/14992027.2020.1721577

Page, T. A., Harrison, M., Moeller, M. P., Oleson, J., Arenas, R. M., & Spratford, M. (2018). Service provision for children who are hard of hearing at preschool and elementary school ages. *Language, Speech, and Hearing Services in Schools*, *49*(4), 965–981. https://doi.org/10.1044/2018_LSHSS-17-0145

Panacek, E. A. (2007). Performing chart review studies. *Air Medical Journal*, *26*(5), 206–210. https://doi.org/10.1016/j.amj.2007.06.007

Park, L. R., Gagnon, E., Thompson, E., & Brown, K. (2019). Age at full-time use predicts language outcomes better than age of surgery in children who use cochlear implants. *American Journal of Audiology*, *28*(4), 986–992. https://doi.org/10.1044/2019_AJA-19-0073

Paruthi, S., Brooks, L. J., Ambrosio, C. D., Hall, W. A., Kotagal, S., Lloyd, R. M., Malow, B. A., Maski, K., Nichols, C., Quan, S. F., Rosen, C. L., Troester, M. M., & Wise, S. (2016). Consensus statement of the American Academy of Sleep Medicine on the recommended amount of sleep for healthy children: Methodology and discussion. *Journal of Clinical Sleep Medicine*, *12*(11), 1549–1561. https://doi.org/10.5664/jcsm.6288

Peer, S. (2015). Turning up the volume on hearing loss in South Africa. *South African Medical Journal*, *105*(1), 31–32. https://doi.org/10.7196/SAMJ.9218

Pekár, S., & Brabec, M. (2018). Generalized estimating equations: A pragmatic and flexible approach to the marginal GLM modelling of correlated data in the behavioural sciences. *Ethology*, *124*(2), 86–93. https://doi.org/10.1111/eth.12713

Percy-Smith, L., Hallstrøm, M., Josvassen, J. L., Mikkelsen, J. H., Nissen, L., Dieleman, E., & Cayé-Thomasen, P. (2018). Differences and similarities in early vocabulary development between children with hearing aids and children with cochlear implant enrolled in 3-year auditory verbal intervention. *International Journal of Pediatric Otorhinolaryngology*, *108*, 67–72. https://doi.org/10.1016/j.ijporl.2018.02.030

Percy-Smith, L., Tønning, T. L., Josvassen, J. L., Mikkelsen, J. H., Nissen, L., Dieleman, E., Hallstrøm, M., & Cayé-Thomasen, P. (2018). Auditory verbal habilitation is associated with improved

outcome for children with cochlear implant. *Cochlear Implants International*, *19*(1), 38–45. https://doi.org/10.1080/14670100.2017.1389020

Persson, A. E., Al-Khatib, D., & Flynn, T. (2020). Hearing aid use, auditory development, and auditory functional performance in Swedish children with moderate hearing loss during the first 3 years. *American Journal of Audiology*, *29*(3), 436–449. https://doi.org/10.1044/2020_AJA-19-00092

Peters, K., & Anderson, K. (2019). Hearing aid and hearing assistive technology non-use in classrooms: A survey of teachers of the deaf, audiologists, and speech-language pathologists. *Journal of Educational, Pediatric & (Re)Habilitative Audiology*, *24*, 1–21.

Preston, E., Twohig, M., & Muñoz, K. (2017). Parent-professional partnerships: Managing behavior to increase hearing aid use. *Perspectives of the ASHA Special Interest Groups*, *2*(9), 66–71. https://doi.org/10.1044/persp2.sig9.66

Ramsden, J. D., Gordon, K. A., Aschendorff, A., Borucki, L., Bunne, M., Burdo, S., Garabedian, N., Grolman, W., Irving, R., Lesinski-Schiedat, A., Loundon, N., Manrique, M., Martin, J., Raine, C., Wouters, J., & Papsin, B. C. (2012). European bilateral pediatric cochlear implant forum consensus statement. *Otology & Neurotologyogy & Neurotology*, *33*(4), 561–565. https://s3.amazonaws.com/academia.edu.documents/42587989/European_Bilateral_Pediatric_Cochlear_Im20160211-25504-1ym1bjx.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1536252054&Signature=mdLwO1r5u9ehsA4wRnAf7FVq2e8%3D&response-content-disposition=inline

Ramsey, T., Svider, P. F., & Folbe, A. J. (2018). Health burden and socioeconomic disparities from hearing loss: A global perspective. *Otology and Neurotology*, *39*(1), 12–16. https://doi.org/10.1097/MAO.0000000000001630

Rhoades, E. A. (2018). A commentary on bimodal bilingual early intervention for children with hearing loss: Some unresolved issues. *Volta Review*, *117*(1–2), 146–161. https://doi.org/10.17955/tvr.117.1.2.783

Samy, H., Mohamed, R., & Ahmed, M. (2018). Audiological profile of children with hearing loss in upper Egypt. *Egyptian Journal of Ear, Nose, Throat and Allied Sciences*, *19*(3), 69–74. https://doi.org/10.21608/ejentas.2018.4915.1034

Saunders, G. H., Bott, A., & Tietz, L. H. B. (2020). Hearing care providers' perspectives on the utility of datalogging information. *American Journal of Audiology*, *29*(3S), 610–622. https://doi.org/10.1044/2020_AJA-19-00089

Scarinci, N., Erbasi, E., Moore, E., Ching, T. Y. C., & Marnane, V. (2018). The parents' perspective of the early diagnostic period of their child with hearing loss: Information and support. *International Journal of Audiology*, *57*(S2), S3–S14. https://doi.org/10.1080/14992027.2017.1301683

Scheepers, L., Swanepoel, D. W., & Le Roux, T. (2014). Why parents refuse newborn hearing screening and default on follow-up rescreening — A South African perspective. *International Journal of Pediatric Otorhinolaryngology*, *78*(4), 652–658. https://doi.org/10.1016/j.ijporl.2014.01.026

Sevinç, Ş., & Şenkal, Ö. A. (2021). Parent participation in early intervention/early childhood hearing impairment program. *Nigerian Journal of Clinical Practice*, *24*(2), 254–261. https://doi.org/10.4103/njcp.njcp_139_20

Sharma, S. D., Cushing, S. L., Papsin, B. C., & Gordon, K. A. (2020). Hearing and speech benefits of cochlear implantation in children: A review of the literature. *International Journal of Pediatric Otorhinolaryngology*, *133*, Article e109984. https://doi.org/10.1016/j.ijporl.2020.109984

Simon, F., Haggard, M., Rosenfeld, R. M., Jia, H., Peer, S., Calmels, M. N., Couloigner, V., & Teissier, N. (2018). International consensus (ICON) on management of otitis media with effusion in children. *European Annals of Otorhinolaryngology, Head and Neck Diseases*, *135*(1), S55–S57. https://doi.org/10.1016/j.anorl.2017.11.009

Singh, G., Barr, C., Montano, J., English, K., Russo, F., & Launer, S. (2017). Family-centered audiology care: Emotion and reason in hearing healthcare. *Hearing Review*, *24*(5), 30–32. https://doi.org/10.3389/fpsyg.2016.00780/pdf

Sininger, Y. S., Grimes, A., & Christensen, E. (2010). Auditory development in early amplified children: Factors influencing auditory-based communication outcomes in children with hearing loss. *Ear & Hearing*, *31*(2), 166–185. https://doi.org/10.1097/AUD.0b013e3181c8e7b6

Smith, J., Wolfe, J., & Ching, T. Y. C. (2015). Lessons from LOCHI. *Hearing Journal*, *69*(6), 18–23. https://doi.org/10.1097/01.HJ.0000484547.75301.11

South African Government. (n.d.). *Disability grant*. Retrieved October 31, 2019, from https://www.gov.za/services/social-benefits/disability-grant

Stander, M. (2019). *Late acquisition of South African Sign Language of deaf children from hearing parents: A sociolinguistic perspective [Unpublished master's dissertation, University of the Free State, South Africa]*. University of the Free State, South Africa.

Statistics South Africa. (2016). *Community survey 2016 [Statistical release P0301]*. http:///www.statssa.gov.za

Statistics South Africa. (2018). Provincial profile: Western Cape. [Community Survey 2016. Report 03-01-07]. In *Statistics South Africa*. www.statssa.gov.zainfo@statssa.gov.za

Steuerwald, W., Windmill, I., Scott, M., Evans, T., & Kramer, K. (2018). Stories from the webcams: Cincinnati children's hospital medical center audiology telehealth and pediatric auditory device services. *American Journal of Audiology*, *27*(3 Special Issue), 391–402. https://doi.org/10.1044/2018_AJA-IMIA3-18-0010

Stevens, G., Flaxman, S., Brunskill, E., Mascarenhas, M., Mathers, C. D., & Finucane, M. (2013). Global and regional hearing impairment prevalence: An analysis of 42 studies in 29 countries. *European Journal of Public Health*, *23*(1), 146–152. https://doi.org/10.1093/eurpub/ckr176

Stiles, D. J., Bentler, R. A., & McGregor, K. K. (2012). The speech intelligibility index and the pure-tone average as predictors of lexical ability in children fit with hearing aids. *Journal of Speech, Language, and Hearing Research*, *55*(3), 764. https://doi.org/10.1044/1092-4388(2011/10-0264)

Störbeck, C., & Young, A. (2016). The HI HOPES data set of deaf children under the age of 6 in South Africa: Maternal suspicion, age of identification and newborn hearing screening. *BMC Pediatrics*, *16*(1), 1–10. https://doi.org/10.1186/s12887-016-0574-1

Thomas, E. S., & Zwolan, T. A. (2019). Communication Mode and Speech and Language Outcomes of Young Cochlear Implant Recipients: A Comparison of Auditory-Verbal, Oral Communication, and Total Communication. *Otology and Neurotology*, *40*(10), E975–E983. https://doi.org/10.1097/MAO.0000000000002405

Thompson, C. B., & Panacek, E. A. (2007). Sources of bias in research design. *Air Medical Journal*, *26*(4), 166–168. https://doi.org/10.1016/j.amj.2007.04.006

Thompson, E., Benítez-Barrera, C. R., Angley, G. P., Woynaroski, T., & Tharpe, A. M. (2020). Remote microphone system use in the homes of children with hearing loss: Impact on caregiver communication and child vocalizations. *Journal of Speech, Language, and Hearing Research*, *63*(2), 633–642. https://doi.org/10.1044/2019_JSLHR-19-00197

Tomblin, J. B., Harrison, M., Ambrose, S. E., Walker, E. A., Oleson, J. J., & Moeller, M. P. (2015). Language outcomes in young children with mild to severe hearing loss. *Ear & Hearing*, *36*(S1), 76S-91S. https://doi.org/10.1097/AUD.0000000000000219

Tomblin, J. B., Oleson, J., Ambrose, S. E., Walker, E. A., McCreery, R. W., & Moeller, M. P. (2020). Aided hearing moderates the academic outcomes of children with mild to severe hearing loss. *Ear & Hearing*, *41*(4), 775–789. https://doi.org/10.1097/AUD.0000000000000823

Tomblin, J. B., Oleson, J., Ambrose, S. E., Walker, E. A., & Moeller, M. P. (2020). Early literacy predictors and second grade outcomes in children who are hard of hearing. *Child Development*, *91*(1), e179–e197. https://doi.org/10.1111/cdev.13158

Tomblin, J. B., Walker, E. A., McCreery, R. W., Arenas, R. M., Harrison, M., & Moeller, M. P. (2015). Outcomes of children with hearing loss: Data collection and methods. *Ear & Hearing*, *36*(S1), 14S-23S. https://doi.org/10.1097/AUD.0000000000000212.Outcomes

Tran, T., Wang, Y., Smith, M. J., Sharp, B., Ibieta, T., Webb, J., Jumonville, W., Peat, M., & Berry, S. (2016). Time trend and factors associated with late enrollment in early intervention among children with permanent hearing loss in Louisiana 2008-2013. *Journal of Early Hearing Detection and Intervention*, *1*(2), 17–22. https://doi.org/10.15142/T3T015

University of Pretoria. (2018). *Code of ethics for research [Rt 429/99]*. https://doi.org/https://www.up.ac.za/media/shared/Legacy/sitefiles/file/45/2875/code_ethics_researchrt42999.pdf

University of South Africa. (2016). *Policy on research ethics*. https://www.unisa.ac.za/static/corporate_web/Content/Colleges/CLAW/Research/Docs/Policy on Research Ethics - rev appr - Council - 15.09.2016.pdf

Vassar, M., & Holzmann, M. (2013). The retrospective chart review: Important methodological considerations. *Journal of Educational Evaluation for Health Professions*, *10*(12), 1–7. https://doi.org/10.3352/jeehp.2013.10.12

Vos, B., Noll, D., Pigeon, M., Bagatto, M., & Fitzpatrick, E. M. (2019). Risk factors for hearing loss in children: A systematic literature review and meta-analysis protocol. *Systematic Reviews*, *8*(1), 1–7. https://doi.org/10.1186/s13643-019-1073-x

Walker, E. A. (2020). Evidence-based practices and outcomes for children with mild and unilateral hearing loss. *Language, Speech, and Hearing Services in Schools*, *51*(1), 1–4. https://doi.org/10.1044/2019_LSHSS-19-00073

Walker, E. A., Holte, L., McCreery, R. W., Spratford, M., Page, T., & Moeller, M. P. (2015). The influence of hearing aid use on outcomes of children with mild hearing loss. *Journal of Speech, Language, and Hearing Research*, *58*(5), 1611–1625. https://doi.org/10.1044/2015_JSLHR-H-

15-0043

Walker, E. A., Holte, L., Spratford, M., Oleson, J. J., Welhaven, A., & Harrison, M. (2014). Timeliness of service delivery for children with later-identified mild to severe hearing loss. *American Journal of Audiology*, *23*(21), 116–128. https://doi.org/10.1007/s10955-011-0269-9.Quantifying

Walker, E. A., McCreery, R. W., Spratford, M., Oleson, J. J., Van Buren, J., Bentler, R., Roush, P., & Moeller, M. P. (2015). Trends and predictors of longitudinal hearing aid use for children who are hard of hearing. *Ear & Hearing*, *36*(1), 38–47. https://doi.org/10.1097/AUD.0000000000000208

Walker, E. A., Spratford, M., Ambrose, S. E., Holte, L., & Oleson, J. (2017). Service delivery to children with mild hearing loss: Current practice patterns and parent perceptions. *American Journal of Audiology*, *26*(1), 38–52. https://doi.org/10.1044/2016_AJA-16-0063

Walker, E. A., Spratford, M., Moeller, M. P., Oleson, J., Ou, H., Roush, P., & Jacobs, S. (2013). Predictors of hearing aid use time in children with mild-to-severe hearing loss. *Language Speech and Hearing Services in Schools*, *44*(1), 73–88. https://doi.org/10.1044/0161-1461(2012/12-0005)

Walliman, N. (2011). *Research methods: The basics*. Routledge. http://www.dphu.org/uploads/attachements/books/books_2531_0.pdf

Watermeyer, J., Kanji, A., & Sarvan, S. (2017). The first step to early intervention following diagnosis: Communication in pediatric hearing aid orientation sessions. *American Journal of Audiology*, *26*(4), 576–582. https://doi.org/10.1044/2017_AJA-17-0027

Watson, L. M., Archbold, S. M., & Nikolopoulos, T. P. (2006). Children's communication mode five years after cochlear implantation: changes over time according to age at implant. *Cochlear Implants International*, *7*(2), 77–91. https://doi.org/10.1179/146701006807508061

Weir, C., & Ayliff, D. (2014). Does deafness spell disaster? An analysis of the written English levels of deaf children in the Nelson Mandela Metropole, South Africa. *Perspectives in Education*, *32*(4), 134–148. http://www.scopus.com/inward/record.url?eid=2-s2.0-84924152090&partnerID=40&md5=3203cc423daa7c05d1b535d98e79701a

Weisleder, A., & Fernald, A. (2013). Talking to children matters: Early language experience strengthens processing and builds vocabulary. *Psychological Science*, *24*(11), 2143–2152. https://doi.org/10.1177/0956797613488145

Weston, M., Muñoz, K. F., & Blaiser, K. (2014). Monitoring progress for children with hearing loss. *Perspectives on Hearing and Hearing Disorders in Childhood*, *24*(2), 74–81. https://doi.org/10.1044/hhdc24.2.74

Whicker, J. J., Muñoz, K., & Nelson, L. H. (2019). Parent challenges, perspectives and experiences caring for children who are deaf or hard-of-hearing with other disabilities: A comprehensive review. *International Journal of Audiology*, *58*(1), 5–11. https://doi.org/10.1080/14992027.2018.1534011

Whicker, J. J., Smith, B. K., & Muñoz, K. (2020). Parent and professional perceptions and feedback on the content of an eHealth hearing aid learning series for parents of children who are deaf or hard-of-hearing. *Perspectives of the ASHA Special Interest Groups*, *5*(6), 1514–1523. https://doi.org/10.1044/2020_persp-20-00093

Wilkinson, K. (2016). Editor's column: A reflection on studies using retrospective record review. *American Journal of Speech-Language Pathology*, *25*(4), 1–2. https://doi.org/10.1044/2016

Wiseman, K. B., & Warner-Czyz, A. D. (2018). Inconsistent device use in pediatric cochlear implant users: Prevalence and risk factors. *Cochlear Implants International*, *19*(3), 131–141. https://doi.org/10.1080/14670100.2017.1418161

Wolfe, J., & Neumann, S. (2016). Implantable hearing technologies and auditory verbal therapy. In W. Estabrooks, K. MacIver-Lux, & E. A. Rhoades (Eds.), *Auditory-verbal therapy for young children with hearing loss and their families and the practitioners who guide them*. Plural Publishing, Inc.

World Health Organization. (n.d.). *Grades of hearing impairment*. WHO; World Health Organization. Retrieved December 2, 2019, from https://www.who.int/pbd/deafness/hearing_impairment_grades/en/

World Health Organization. (1991). *Report of the informal working group on prevention of deafness and hearing impairment programme planning, Geneva, 18-21 June 1991.*

World Health Organization. (2016). *Childhood hearing loss: Strategies for prevention and care*. http://www.who.int/about/licensing/copyright_form/index.html

World Health Organization. (2020). *Basic ear and hearing care resource*. World Health Organization. licence: CC BY-NC-SA 3.0 IGO. http://apps.who.int/iris

World Health Organization. (2021). *World report on hearing*. World Health Organization. licence: CC%0ABY-NC-SA 3.0 IGO. https://www.who.int/publications/i/item/world-report-on-hearing

Yoshinaga-Itano, C. (2003). From screening to early identification and intervention: Discovering predictors to successful outcomes for children with significant hearing loss. *Journal of Deaf Studies and Deaf Education*, *8*(1), 11–30. https://doi.org/10.1093/deafed/8.1.11

Yoshinaga-Itano, C. (2014). Principles and guidelines for early intervention after confirmation that a child is deaf or hard of hearing. *Journal of Deaf Studies and Deaf Education*, *19*(2), 143–175. https://doi.org/10.1093/deafed/ent043

Yoshinaga-Itano, C., Sedey, A. L., Coulter, D. K., & Mehl, A. L. (1998). Language of early- and later-identified children with hearing loss. *Pediatrics*, *102*(5), 1161–1171. https://doi.org/10.1542/peds.102.5.1161

Yuan, W., Beaulieu-Jones, B. K., Yu, K. H., Lipnick, S. L., Palmer, N., Loscalzo, J., Cai, T., & Kohane, I. S. (2021). Temporal bias in case-control design: Preventing reliable predictions of the future. *Nature Communications*, *12*(1). https://doi.org/10.1038/s41467-021-21390-2

6. APPENDICES

Appendix A: Institutional review board clearance (HUM010/0219) from the Research Ethics Committee of The Faculty of Humanities, University of Pretoria.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Humanities 100. 1919 - 2019

Research Ethics Committee

1 March 2019

Dear Ms S Booysen

Project Title:	Predictors of hearing technology use in South African children with hearing loss
Researcher:	Ms S Booysen
Supervisor:	Dr TE le Roux
Department:	Speech Language Path and Aud
Reference number:	HUM010/0219
Degree:	Masters

Thank you for the application that was submitted for ethical consideration.

The Research Ethics Committee notes that this is a literature-based study and no human subjects are involved.
The application has been **approved** on 28 February 2019 with the assumption that the document(s) are in the public domain. Data collection may therefore commence, along these guidelines.

Please note that this approval is based on the assumption that the research will be carried out along the lines laid out in the proposal. However, should the actual research depart significantly from the proposed research, a new research proposal and application for ethical clearance will have to be submitted for approval.

We wish you success with the project.

Sincerely

Prof Maxi Schoeman
Deputy Dean: Postgraduate Studies and Ethics
Faculty of Humanities
UNIVERSITY OF PRETORIA
e-mail:PGHumanities@up.ac.za

CC: Ms EP Pretorius (Supervisor)

Fakulteit Geesteswetenskappe
Lefapha la Bomotho

Research Ethics Committee Members: Prof MME Schoeman (Deputy Dean); Prof KL Harris; Mr A Bizos; Dr L Blokland; Dr K Booysens; Dr A-M de Beer; Ms A dos Santos; Dr R Fasselt; Ms KT Govinder; Andrew; Dr E Johnson; Dr W Kelleher; Mr A Mohamed; Dr C Puttergill; Dr D Reyburn; Dr M Soer; Prof E Taliard; Prof V Thebe; Ms B Tsebe; Ms D Mokalapa

Appendix B: Agreement between caregivers and the Carel du Toit Centre for de-identified data collection.

INDEMNITY AND AGREEMENT

PARTIES : 1. *CAREL DU TOIT CENTRE, Tygerberg Hospital, Francie van Zijl-Boulevard, Parow*
*(Hereafter called the "**Centre**")*

2. _____ *(Full name and surname of parent / guardian)*

_____ *(Identity Number)*
*(hereafter called the "**Parent**" / "**Guardian**")*

WHEREAS the Parties agreed that

_____ *(Full name and surname)*
*(hereafter called the "**Child**")*

was registered as a pupil at this Centre under certain rules and regulations, the Parties further agree as follows

CONTROL AND SUPERVISION

I, the undersigned Parent / Guardian in my capacity as Parent / Guardian of the Child hereby in rem suam authorise the Principal and Staff of the Centre to control and supervise my Child, for both intramural and extramural activities, during those times / hours for which I have left the Child in the care of the Centre.

INDEMNITY

In my capacity as the natural Parent / Guardian I undertake to indemnify the Centre, Principal, Staff, and / or any authorised and responsible person from the Centre for (which includes, but is not limited to) all injuries, losses, damages, compensation, death, costs and expenses which may result from any event, act or accident of whatever nature, which may result from any activity within or outside the Centre (including school outings and the transport of my Child) involving my Child, while the Child was under the control and supervision of the Centre, Principal, Staff, and / or any authorised and responsible person from the Centre.

MEDICAL EMERGENCIES AND CASUALTIES

I hereby give my permission that in case of any medical incident, emergency or casualty involving my Child, the Centre, Principal, Staff and / or any authorised and responsible person from the Centre is authorised to take all necessary steps for the safeguarding and protection of my Child, which includes, but is not limited to, doctor's treatment or hospitalisation of the Child, should it be impossible to locate the Parent / Guardian. If I can be located, I undertake to immediately take my Child for such treatment.

I indemnify the Centre, Principal, Staff and / or any authorised and responsible person from the Centre from the payment of any accounts, medical costs and / or other costs which may result from medical emergencies and casualties, and I undertake to pay all such costs on demand.

I hereby give my permission for the Centre, Principal, Staff and / or any authorised and responsible person from the Centre to administer basic first aid.

TO MY BEST KNOWLEDGE MY CHILD IS

1. Not allergic to any medicine : ☐ Yes • ☐ No
2. Allergic to the following medication : _____
   _____
3. My Child suffers from the following allergies : _____
   _____
4. My Child needs regular medical treatment for : _____
   _____

PERMISSION FOR PHOTOGRAPHS, TV, VIDEO PROGRAMS AND MEDIA

Carel du Toit / CHAT Centre is an NGO and reliant on donations and public support and therefore we need to share our success stories with the public; through sharing your story, other families with children will be encouraged and given hope. You are being asked to give consent for your child's experiences at the CHAT and Carel du Toit Centre to be shared publically. The ways in which the programme partners may use his / her story and images are outlined below.

I, the undersigned _____ parent / guardian of _____

hereby give consent for the above child to be photographed or filmed, and for his / her name and patient story shared, for publication in : Reports, academic purposes and marketing material (Print media, broadcast media, online media)*

For example :

To an individual or corporate donor, Trustfund, advertisements, newsletters, brochures, audio-visual presentations, radio, TV public service announcements, presentations, lectures, articles, Trust website, Facebook, YouTube, Twitter, other.

I understand that :

- this photograph / film will become the property of the Carel du Toit Centre to be used at their discretion;
- the Carel du Toit is hereby permitted to share the patient's story and details with external publics;
- there is no personal or financial gain involved;
- the information and visuals may be used again in future without notification by the Trust, Centre or media;
- I cannot make any claim against the Carel du Toit Centre.

CONSENT TO RELEASE INFORMATION

I give permission to the Carel du Toit Centre, to have access and copying rights to any of my child's medical, audiological and psychological records. This information may be used for the purpose of research, publication in scientific literature, and to share with appropriate bodies concerned. I understand that learner confidentiality will be maintained at all times unless specific permission to release identifying data is granted by me.

☐ I understand the above and have been asked if I require a translator.

Signature of Parent / Guardian _____ Signature of Principal _____

Contact Number _____ Alternative Contact Number _____

e-Mail Address _____ Date _____

Appendix C: Letter requesting permission to complete research at the Carel du Toit Centre.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Humanities
Department of Speech-Language Pathology and Audiology

2 February 2018

Dear Ms. Combrink
Principal: The Carel du Toit Centre

RE: Permission to use anonymous Carel du Toit Centre data for a research project

I, Surida Booysen, am conducting a research project around hearing technologies use in children and the factors that influence usage. I am writing to request permission to use the anonymous data from Carel du Toit Centre learner files for my research project entitled, **Trends and Predictors Of Hearing Technology Use In Children.**

Purpose: The purpose of the project is to describe the hearing technology use of the participants, i.e. past and present learners at the Carel du Toit Centre and to determine if there are factors that are either negative of positie predictors of hearing technology usage. The participants will be described regarding their age, hearing loss and family factors and the results will be compared with results of previous findings.

Data collection: All files of the children enrolled in the Centre will be included as participants only if their parents/guardians provided consent for data-collection for research purposes as part of their admittance into the Carel du Toit program. An electronic datasheet will be implemented so that I can systematically document and track the data collected. I undertake to remove all identifying information from the final reports. I also assure you that I will not disturb the normal school routine with this project or cause any financial implications for the Centre.

Risks: There are no risks associated with this study for either the families of Carel du Toit or the Centre itself.

Confidentiality: Data and information obtained will be handled with the strictest confidentiality and no identifying data will be disclosed. Anonymity of participants will be guaranteed at all times with the assignment of a code per participant.

Release of findings: The results from this study will result in journal publication, possible conference presentations with a summary reports provided to the Centre itself

Expected contributions: There is presently no data available on the hearing technology usage in South African children. As Carel du Toit is a leading program in the habilitation of children with hearing loss in Southern Africa, I believe that the outcomes will be valuable to the intervention services provided.

You are most welcome to discuss my request further or contact me on 083 664 8644 for more information. If permission is granted, you are requested to sign a letter of consent.

Sincerely

Surida Booysen
M. Audiology Student

Prof. De Wet Swanepoel
Supervisor

Fakulteit Geesteswetenskappe
Departement Spraak-taalpatologie en Oudiologie
Lefapha la Bomotho
Kgoro ya Phatholosi ya Polelo-Molemo le Go kwa

Appendix D: Permission to the researcher to access data at the Carel Du Toit Centre.

Carel du Toit Centre
Cape Town
PO Box 19130
Tygerberg
7505

Tel: 021 938 5303
Fax: 021 932 5104
Email: hoof@careldutoit.co.za
Website: www.careldutoit.co.za

Carel du Toit
Waar dowe kinders leer praat
Where deaf children learn to speak

DATE: 12 February 2018

To whom it may concern:

PERMISSION TO ACCESS DATA OF CAREL DU TOIT CENTRE: RESEARCH PROJECT

Herewith, I **Adri Combrinck**, principal, give informed consent and permission on behalf of the Carel du Toit Centre to Surida Booysen from the University of Pretoria to use the anonymous Carel du Toit Centre data from learner files with the intent to report results for her project entitled: *"Predictors of Hearing Technology Use in Children"*. We will provide you with files dating back to 1 January 2010. I have received enough information about this project and have been allowed to ask questions.

Sincerely,

Adri Combrinck
Principal: Carel du Toit Centre

Appendix E: Article submission accepted for publication in the International Journal of Audiology

From: International Journal of Audiology <onbehalfof@manuscriptcentral.com>
Sent: 02 April 2021 8:48 PM
To: suridab@gmail.com
Cc: jclark@utdallas.edu
Subject: International Journal of Audiology - Decision on Manuscript ID TIJA-2020-12-0622.R1

MS: "Predictors of hearing technology use in children"
MS#: TIJA-2020-12-0622.R1

Dear Ms. Booysen:

Thank you for submitting your above listed revised manuscript. Based on the recommendations from our expert reviewers, it is a pleasure to accept your above mentioned manuscript in the International Journal of Audiology.

At this time, your manuscript will be sent to the publisher for the final production processes. The journal issue in which your article will be assigned requires at least 4-5 months to reach formal electronic publication. Page proofs and copyright release websites will be sent to you via email during part of the production phases. Please be sure to check your inbox and SPAM/Junk Mail (in case the email lands in the wrong place). It is very important that you read your page proofs carefully and return them promptly to production so that your manuscript can be published on schedule. After you review your page proofs your article will be finalized to make it available to those interested by navigating to the Taylor & Francis Early Online publication website with email announcements distributed globally. You and others will be able to view your article, along with the newest International Journal of Audiology online manuscripts at the website. Please keep in mind that the early online (electronic) publication of your article is considered formal publication with a unique assigned DOI.

We want to increase the impact of your article, and we work with authors to ensure your work reaches the widest possible (and most appropriate) audiences. Discover some simple yet effective ways to highlight your research at https://authorservices.taylorandfrancis.com/ensuring-your-research-makes-an-impact/.

Thank you for this fine contribution. On behalf of the Editors of the International Journal of Audiology, we look forward to your continued contributions to the Journal. Of particular importance is that you consider accepting the offer to review papers for IJA if/when asked. Finding seasoned authors to review papers is a critically important component of the peer review process and your assistance in this area would be most appreciated.

Sincerely,

Jackie L Clark, PhD
Managing Editor
International Journal of Audiology
jclark@utdallas.edu