mHEALTH-SUPPORTED HEARING HEALTH TRAINING FOR EARLY CHILDHOOD DEVELOPMENT PRACTITIONERS: AN INTERVENTION STUDY

by

DIVAN DU PLESSIS

(17170941)

In fulfilment of the requirements for the degree **MA Audiology** in the Department of Speech-Language Pathology and Audiology, Faculty of Humanities, University of Pretoria

SUPERVISORS:

Prof Faheema Mahomed-Asmail

Prof Talita le Roux

Prof De Wet Swanepoel

July 2023

Divan du Plessis

Department of Speech-Language Pathology and Audiology

University of Pretoria

Pretoria

South Africa

Divanjhg@gmail.com

UNIVERSITY OF PRETORIA

FACULTY OF HUMANITIES

DEPARTMENT OF SPEECH-LANGUAGE PATHOLOGY AND AUDIOLOGY

PLAGIARISM DECLARATION

Full Name: **Divan du Plessis**

Student Number: **17170941**

Degree/ Qualification: **MA Audiology**

Title of Dissertation:

MHEALTH-SUPPORTED HEARING HEALTH TRAINING FOR EARLY CHILDHOOD

DEVELOPMENT PRACTITIONERS: AN INTERVENTION STUDY

I declare that this thesis is my original work. Where secondary material is used and has been carefully acknowledged and referenced per the university requirements.

I understand plagiarism and I am aware of university policy and its implications.

07/07/2023

_____   _____

SIGNATURE   **DATE**

III

ETHICS STATEMENT

The author, whose name appears on this dissertation's title page, has obtained, for the research described in this work, the applicable research ethics approval.

The author declares that he has observed the ethical standards required in the University of Pretoria's Code of ethics for researchers and the Policy guidelines for responsible research.

ACKNOWLDGEMENTS

The author would like to acknowledge the following individuals for their unique contributions to this master's dissertation:

- To my supervisors and co-authors, thank you for your insight, counselling, and encouragement at each meeting throughout the years. Each of you invested in me by providing support, giving perspective, and guiding me throughout the process. It has been an honour to gain knowledge from each supervisor.

- To Tersia and her team, without your dedication and hard work with data collection, this would not have been possible. Thank you for everything you've done for me and this study and especially what you're doing in the community.

- To my parents, Jacques, and Carina. Thank you for the tough love, every phone call and words of advice throughout this process. Allowing me to stay a little longer for the parental love and home cooked meals when I needed it.

- To all participants, thank you to everyone who contributed to this study for taking the time and providing insightful feedback.

- To all of my friends and fellow Audiology Master students. Thank you for your support, your patient listening and for allowing me to vent in the times I needed it.

Without the abovementioned individuals, this master's journey would not be possible. Thank you for humbling me and for providing me with every ounce of strength along the way.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

APA	American Psychological Style
ECD	Early Childhood Development
LMIC	Low-middle income country
WSR	Wilcoxon signed-rank
UMIC	Upper-middle income country
SES	Socioeconomic status
WHO	World Health Organization
HL	Hearing loss
ICF	International Classification of Functioning, Disability and Health
EHC	Ear and Hearing Care
EHDI	Early Hearing Detection and Intervention services
UNHS	Universal Newborn Hearing Screening
JCIH	Joint Committee on Infant Hearing
CHW	Community Health Care Worker
PEHC	Primary Ear and Hearing Care
mHealth	Mobile Health
AI	Artificial intelligence
COVID	Coronavirus Disease
DOB	Date Of Birth
SPSS	Statistical Package for the Social Sciences
IBM	International Business Machines
KW	Kruskal-Wallis
SD	Standard deviation

PUBLICATIONS AND RESEARCH OUTPUTS

The findings have been published as an article:

du Plessis, D.; Mahomed-Asmail, F.; le Roux, T.; Graham, M.A.; de Kock, T.; van der Linde, J.; Swanepoel, D.W. mHealth-Supported Hearing Health Training for Early Childhood Development Practitioners: An Intervention Study. *Int. J. Environ. Res. Public Health* **2022**, *19*, 14228. https://doi.org/10.3390/ ijerph192114228

Findings have also been presented:

du Plessis, D.; Mahomed-Asmail, F.; le Roux, T.; Graham, M.A.; de Kock, T.; van der Linde, J.; Swanepoel, D.W. mHealth-Supported Hearing Health Training for Early Childhood Development Practitioners: An Intervention Study. *24th Annual Conference Association of Medical Councils of Africa*, Sun City Resort, South Africa. 2 - 6 October 2022.

du Plessis, D.; Mahomed-Asmail, F.; le Roux, T.; Graham, M.A.; de Kock, T.; van der Linde, J.; Swanepoel, D.W. mHealth-Supported Hearing Health Training for Early Childhood Development Practitioners: An Intervention Study. *16th Congress of European Federation of Audiology Societies 2023,* Sibenik, Croatia. 3 - 6 May 2023.

du Plessis, D.; Mahomed-Asmail, F.; le Roux, T.; Graham, M.A.; de Kock, T.; van der Linde, J.; Swanepoel, D.W. mHealth-Supported Hearing Health Training for Early Childhood Development Practitioners: An Intervention Study. *4th Virtual Conference on Computational Audiology 2023,* Virtual, Ms Teams. 29 - 30 June 2023.

FORMATTING

This research dissertation used the American Psychological Association (APA) 7th edition referencing style.

The formatting style of chapter three (publication above) may differ from the rest of the document as the journal's format was used to compile the submitted article.

ABSTRACT

Introduction: Healthy hearing is important for early childhood development. Early childhood interventions are required for 250 million children under the age of five in low- and middle-income countries (LMICs). One of the most prevalent developmental disorders is hearing loss (HL), which affects an estimated 34 million children globally. Furthermore, an estimated 60% of childhood HL is preventable and can be avoided through public health interventions. The key to effective management and, consequently, positive outcomes in early development is early detection of a hearing loss. Early Childhood Development (ECD) centres serve as a front-line healthcare service in LMICs and low-income communities, with ECD practitioners also serving as primary caregivers. Although the adaptation and evolvement of an ECD practitioner's role can be critical in providing services related to identifying HL, referring, and providing support, more education on aspects of hearing health in children is required. ECD practitioners should prioritize hearing health training and promotion, but training opportunities are limited, particularly in LMICs. Using mHealth approaches has the potential to provide ECD practitioners with scalable ear and hearing training. The purpose of this study was to investigate the effect of an mHealth training intervention program for ECD practitioners to improve knowledge and perceptions of hearing health in young children.

Method: An experimental one-group pre-post-test study included ECD practitioners working with children between birth and six years old across 31 neighbouring communities in the Western Cape Province, South Africa. Hearing health training was provided using WhatsApp messages that included infographics and voice notes. Knowledge and perceptions regarding hearing and hearing-related problems in children were surveyed pre-training, directly post-training, and six months post-training. A knowledge score was determined for each survey to determine differences in knowledge scores across the three longitudinal surveys. In addition, a qualitative component described ECD practitioners' experiences of the training information and its application during a six-month period after initial training.

Results: ECD practitioners (n=1012) between 17 and 71 years of age (mean 37.67, SD 10.78) received the mHealth training programme and completed both the pre-and post-training surveys. A total of 232 ECD practitioners between 19 and 65 years of age (mean 36.97, SD 10.49) also completed the six-month post-training survey. Overall, knowledge scores indicated a significant improvement from pre- to post-training (*WSR*=-22.491; *P*<.001). Based on linear regression analysis, participants' language (*β*=2.821, *t*=7.058, *P* =<.001) and work position at ECD centres or schools (*β*=1.692, *t*=3.161, *P*=.002) were significant contributors to improved knowledge scores. Six-month post-training knowledge scores were sustained. Content analysis of ECD practitioners' application of the training information six months post-training indicated improved awareness, practical application, better assistance for hearing problems and widespread advocacy.

Conclusion: The mHealth training programme supports improved knowledge and perceptions regarding the hearing health of young children among ECD practitioners. mHealth hearing health training can be a sustainable and effective intervention with improved knowledge scores maintained six months post training. Training ECD practitioners with an mHealth approach is a scalable, low-cost intervention that can support primary and secondary prevention of childhood HL, particularly in LMICs.

Keywords

mHealth

community-based

telecare

hearing health

education and training

early childhood development

intervention

CHAPTER 1

INTRODUCTION AND RATIONALE

1.1 INTRODUCTION

1.1.1   *Early Childhood Development*

Early Childhood Development (ECD) refers to the physical, communication, motor, emotional and cognitive development from birth to nine years of age (Van Niekerk et al., 2017). More than 250 million children, younger than five residing in low- and middle-income countries (LMICs) are at developmental risk requiring early childhood interventions (Black et al., 2017). South Africa is classified as an upper-middle-income country (UMIC) yet has a great economic disparity with the majority of the population having a low socioeconomic status (SES) (UNFPA ESARO, 2019). As such, vulnerable children having low SES have little resources available to them, are exposed to greater environmental risks and have socio-economic constraints that place them at a higher risk for developmental delays. These vulnerable children need nurturing care, which includes being in an established environment with protection from threats, having caretakers that are sensitive to their health and nutritional needs, and receiving early learning opportunities and interactions that are approachable, emotionally supportive, and developmentally stimulating (World Health Organization, 2018).

1.1.2 Hearing loss in early childhood

Hearing ability and the development thereof plays a crucial role in early childhood development. This is an important period of physiological development and maturation of the hearing system as children already understand simple words and phrases, with the intent to respond, before one year of age (American Speech Language Hearing Association, 2021; Cole & Flexer, 2020 WHO, 2021). Along with their interactions with people, children pick up conversational speech from their environment and start to learn language through natural interactions (Hirsh-Pasek et al., 2015; Rhoades & Duncan,

2017). The ability to hear does not only influence the ability to learn a language, but in turn also shapes children's listening skills, which affects their ability learning to read and write, and influences the development of social skills (Cole & Flexer, 2020).

Children worldwide are at risk of developmental disabilities with more than 90% residing in LMICs (Olusanya et al., 2018). Global HL prevalence for children under five years of age is estimated to be 2.5% with those in LMICs presenting with higher estimated between 2.3% and 3.1% (Olusanya et al., 2018). Hearing loss (HL) is one of the most prevalent developmental disorders with an estimated 34 million children presenting with a disabling HL globally (Chadha et al., 2021; Eksteen et al., 2019 Olusanya & Newton, 2007; WHO, 2020; WHO, 2021).

Children experience and are exposed to numerous factors that can influence their hearing abilities (WHO, 2021). Some of these factors include genetic characteristics and predispositions, and biological, behavioural, and environmental factors (WHO, 2021). These risks are more adverse for children living in lower SES areas and have a greater cumulative effect with an inverse association with hearing losses in those areas (Scholes et al., 2018; Smith et al., 2019). Furthermore, an estimated 60% of childhood HL is preventable (Eksteen et al., 2021; WHO, 2021) and can be averted through the implementation of public health measures which include immunisation, good maternal and childcare practices, early identification, and management of common ear conditions through systematic screenings (WHO, 2021). The main causes of preventable hearing losses in children are chronic ear infections like chronic otitis media, meningitis, and other infections such as measles and mumps (WHO, 2021). Chronic otitis media affects more than 700 million people, mostly children below the age of five years (WHO, 2021) making it one of the most common causes of HL among children (WHO, 2020).

Chronic otitis media, which can be unilateral or bilateral, can be associated with mild-to-moderate conductive HL due to the disruption of the transmissions of sounds through the middle ear (WHO, 2021). The effect of a mild- and unilateral HL are linked to difficulty hearing conversational speech,

especially in noisy environments, and sound localisation (WHO, 2021). The difficulty to hear conversational speech due to a HL can have a cascading effect on early language development as it affects early speech discrimination important for early word learning and the phonotactic rules of language (Stiles et al., 2012). Some hearing losses are therefore a preventable health disparity that can withhold a child from living an enabled life with all access to the opportunities they might otherwise receive. The impact of a HL on an individual can be classified into a functional, social-emotional, and an economic effect, which is interlinked with an individuals' ability to communicate with others (WHO, 2020). Furthermore, the International Classification of Functioning, Disability and Health (ICF) provides a framework which measures health and disability at both an individual and population level (WHO, 2021). The ICF defines a disability not only determined by an individual's HL, but also by their physical, social, and attitudinal environment in which they live, along with their access to quality ear and hearing care (EHC) services (WHO, 2021).

1.1.3 Undetected hearing loss in children

A HL, although greatly detrimental to ECD, can easily be missed especially among young children, which in turn has far-reaching consequences (WHO, 2021; Yousuf Hussein et al., 2018). An undetected or untreated HL in young children is often associated with listening and communication problems, delays in speech and language development, delayed cognitive development and poor academic achievement (Chadha et al., 2021; Ching et al., 2013; Cole & Flexer, 2020; Global Burden of Disease, 2021; Joint Committee on Infant Hearing, 2019; Robertson et al., 2009; WHO, 2016; WHO, 2021; Yoshinaga-Itano, et al., 1998; Yousuf Hussein et al., 2018). These consequences and their effects on development can be ameliorated through the initiation of early hearing detection and intervention services (EHDI), which include services such as universal newborn hearing screening (UNHS) or school-based hearing screening to identify children with a HL and recommend further evaluation and intervention services (JCIH, 2019).

1.1.4 Early hearing detection and intervention services in low-and-middle income countries

Early detection of a HL is the key to effective management and optimal outcomes in early development (WHO, 2021). Language and long-term literacy benefits can be seen for children with hearing losses in countries where EHDI strategies, accompanied by UNHS, were in place (Pimperton et al., 2015). However, EHDI programmes are often not attainable for infants born in LMICs (JCIH, 2007; Swanepoel et al., 2009). The implementation of EHDI services are not effectuated in LMICs where two thirds of the world's children with HL reside (Bezuidenhout et al., 2018; Khoza-Shangase et al., 2021; Olusanya et al., 2004). Children from LMICs are often incapable of reaching their full developmental potential due to socio-economic constraints, high expenditure of resources and health systems being too feeble to manifest the added encumbrance of non-fatal but disabling disorders such as a HL (Grantham-McGregor et al., 2007; Olusanya & Newton, 2007; Swanepoel et al., 2009). Complex ECD problems require multiple points of entry with continued developmental monitoring throughout these vulnerable children's lives. With shortages in EHDI services among LMICs, alternative service delivery options need to be put in place, as hearing is an important cornerstone during ECD (WHO, 2020).

1.1.5 Early Childhood Development centres

ECD centres are community-based stimulation centres that provide nurturing care through ECD programmes and services aimed at alleviating the long-term effects and outcomes of deprivation of basic health and education for vulnerable young children (Van Niekerk et al., 2017). The necessity of ECD centres are rising with an increase of 40.3% in children age three to four and 34.3% age five to six attending ECD centres from 2002 to 2011 (Smit et al., 2021). ECD centres can facilitate primary prevention through education and awareness regarding risk factors for developmental delay and secondary prevention through systematic screenings and early detection programmes. ECD centres can provide protection for children against the long-term negative effects of poor nutrition, inadequate health, lack of education and poverty (Putcha & van der Gaag, 2015). Within LMICs and low SES communities, ECD centres serve as a front-line healthcare service and ECD practitioners also acting as primary caregivers (Smit et al., 2021; Yousuf Hussein et al., 2016). With an estimated 62.1% of

4

children in South Africa living in poverty (Statistics Africa, 2020), ECD centres serve to be an integral part of children's lives. Children living in poverty rarely encounter medical services and ECD centres can provide multiple services for young vulnerable children, one of which is hearing services (Yousuf Hussein et al., 2018). With ECD centres providing health services and ECD practitioners acting as primary care givers within ECD centres in LMICs, the adaptation and evolvement of an ECD practitioner's role can be very important to provide services related to identifying a HL, to refer and to provide support (Smit et al., 2021; Yousuf Hussein et al., 2018).

The WHO (2021) recommends that community health care workers (CHWs) in LMICs be trained to promote and encourage greater prioritisation of prevention, identification, and treatment of HL (Smit et al., 2021; WHO, 2021; Wilson et al., 2017; Yousuf Hussein et al., 2016). The term task-sharing involves the redistribution of clinical tasks among different cadres of health workers through the provision of training and short courses to increase the capacity to take on a specific task like EHC. Training health workers who provide services and undertake health promotion at community and primary levels, can help to improve the knowledge level of communities regarding appropriate EHC practices, can enhance access to EHC services, decrease health disparities, boost efficiency, and enhance access to care and quality of care throughout the life course (WHO, 2021). The shift in providing Primary Ear and Hearing Care (PEHC) training resources to train CHWs has played a very significant role in contributing towards the task-sharing of EHC interventions (WHO, 2021). This has been especially relevant to community and primary healthcare workers regarding awareness, early diagnosis and management, and appropriate referrals (WHO, 2021). A study done by Castro and Zucki (2015) evaluated training provided to CHWs in the field of child hearing health and concluded that training was effective in improving the knowledge of CHWs for them to manage a variety of health promotion and surveillance-related tasks. This showed that PEHC training can have an important effect on service delivery without minimising the importance and need of ECH professionals in LMICs (Castro & Zucki, 2015).

In many LMICs, frontline ECD practitioners play an important role in the primary and secondary health care system by screening and triaging people and educating community members about hearing health (Mantena et al., 2021). ECD practitioners facilitate and mediate learning, observe and assess progress, and support holistic development of children and play a critical role in the prevention and detection of developmental delays in young children, shaping early learning outcomes through developmentally appropriate treatments (Smit et al., 2021). A study by Abraham et al. (2003) investigated the feasibility of training teachers at day-care centres regarding primary ear care and observed an increase in average knowledge scores from 28.4% pre-training to 86% post-training. The training was provided through in-person teaching methods, which included lectures, discussions, role-plays, clinical examinations, and practice sessions (Abraham et al., 2003). A more recent study done by Yousuf Hussein et al. (2018) investigated the knowledge and attitudes of 82 ECD practitioners towards hearing health in LMIC communities. The findings concluded that the knowledge and attitudes of ECD practitioners in the LMIC setting was favourable towards ECD and demonstrated readiness for implementation of hearing screening programmes within ECD facilities (Yousuf Hussein et al., 2018). Even with positive findings, the researchers identified gaps in knowledge regarding the identification methods for a HL and the impact of a HL on children in the classroom setting (Yousuf Hussein et al., 2018). The study identified the need for education on aspects of hearing health in children, such as identifying HL, supporting a child with HL, and the educational impact of HL (Yousuf Hussein et al., 2018). Scalable interventions on hearing health education for ECD practitioners, especially in resource constrained LMICs, must rely on innovative and widely accessible approaches like mHealth, to overcome barriers to accessing ear and hearing health.

1.1.6 mHealth-supported training

Provision of mHealth services is a low-cost, easy to manage service, which can improve access to hearing health care in LMICs (Clark & Swanepoel, 2014; Mahomed-Asmail et al., 2016; Swanepoel et al., 2014; Swanepoel & Clark, 2017). mHealth refers to the utilisation of mobile phones, wireless devices, and digital assistants to improve healthcare delivery (Dugas et al., 2020; Early et al., 2019).

6

In remote LMIC settings, mHealth services provide suitable service delivery where CHWs can connect with experts, receive appropriate feedback, and enhance overall performance and health care delivery (Roess, 2017). Furthermore, mHealth can broaden access to care, reduce medical errors and in turn avoid unnecessary costly interventions, thereby holding true to the promise of improving health outcomes (Cortez et al., 2014). For children from underserved populations, mHealth services can serve as front-line preventative hearing healthcare (Yousuf Hussein et al., 2018). The provision of mHealth services introduce an efficient approach for ECD practitioners with limited training, to successfully be involved in hearing service delivery by recommending appropriate referrals and support (Mahomed-Asmail et al., 2016; Yousuf Hussein et al., 2016). Thus, by harnessing mHealth services, it may reduce the already-limited demand for ear and hearing professionals (Mahomed-Asmail et al., 2016; Yousuf Hussein et al., 2016). Empowering ECD practitioners in these low-resourced settings may hold the potential to overcome barriers that LMICs may hold, such as increasing preventative hearing screening and diagnosis and for accessing EHC in community health care (Mantena et al., 2021). Looking at how mHealth interventions could improve lifestyle behaviours and the management of chronic conditions, recent findings found that mHealth is an effective tool for a wide range of health behaviours (Dugas et al., 2020). The effectiveness of a single text-message reflects the adaptability of mHealth to different content and health domains (Dugas et al., 2020).

An mHealth service delivery approach can also be useful in difficult circumstances, for instance, during a pandemic, where these services can provide an asynchronous point of care and integrate primary EHC with community-based programmes (Yousuf Hussein et al., 2016). In 2020, the COVID-19 pandemic limited many in-person health care services and provided the opportunity for health care services to potentially restructure and reorganise their means of service delivery and training services (Windisch et al., 2020). Innovative mHealth approaches are rapidly becoming important for public health care in LMICs, providing tools for awareness, health promotion campaigns, and services that are accessible and can scale rapidly (Clark & Swanepoel, 2014; Frisby et al., 2022;, 2019; Kazi et al.,

2021; Mahomed-Asmail et al., 2016; Swanepoel et al., 2014; Swanepoel & Clark, 2019; Richardson et al., 2021).

The ubiquity of mobile phones and increased access to the internet have created an opportunity to optimise the implementation of mHealth services into an existing system and potentially increase the efficiency of different service delivery cadres (Dugas et al., 2020; Early et al., 2019; Kazi et al., 2021). mHealth applications have been adopted across multiple professions and adapted for the intent of use in clinical and non-clinical environments (Ojo, 2018; van der Pol et al., 2022). A scoping review by Early et al. (2019) reviewed ten years of research pertaining to mHealth technologies and interventions among CHW globally and found that mHealth technologies appear to have the potential to be a useful tool for strengthening recruitment and training of lay health workers to carry out mHealth interventions. Text-message interventions' significant benefits include reminders, alerts, education, motivation, and prevention (Ojo, 2018; Marcolino et al., 2018). Individualised motivating SMS text-messages or reminders are one example of how digitisation allows health promotion and preventive interventions to be customised and tailored to the requirements of people (Stark et al., 2022). A systematic review by Richardson et al. (2020) investigated the effect of using text messages on caregiver behaviour and child outcomes. Results indicated that text messages can be an effective influencing tool on caregiver behaviour and child health outcomes and be of great value, especially for ECD practitioners (Richardson et al., 2020).

Hearing health training and promotion through mHealth has the potential to support preventative hearing healthcare services for young children from underserved populations, but there is a lack of evidence on hearing health promotion through mHealth (Frisby et al., 2022; Stark et al., 2022). A recent scoping review by Frisby et al. (2022) on mHealth and HL identified only three papers reporting hearing health promotion; all published recently in 2021. Employing mHealth to train personnel like ECD practitioners who serve as front-line workers in vulnerable communities can promote and support primary and secondary prevention of childhood HL. However, limited evidence exists regarding the

8

effectiveness of mHealth training interventions for ECD practitioners on hearing health in young children (Richardson et al., 2021).

1.2 RATIONALE

Scalable interventions for hearing health education and promotion could leverage innovative approaches like mHealth (mobile health) to make ear and hearing health training for ECD practitioners more accessible. With the implementation of mHealth, barriers, including limited availability of hearing health professionals, transportation, time, expenses, and resource availability, can be addressed (Frisby et al., 2022). Utilising mHealth to educate and promote hearing health can enhance the capabilities of ECD practitioners to substantially reduce the morbidity related to ear and hearing disorders (Dawood et al., 2021; Mantena et al., 2021). Therefore, this study investigated the effect of an mHealth training intervention programme on ECD practitioners' knowledge and perceptions of hearing in young children.

CHAPTER 2

METHODOLOGY

2.1 RESEACH OBJECTIVES

The main objective was to determine the effect of an mHealth training programme for ECD practitioners on their knowledge and perceptions of hearing health in young children.

Secondary objectives

1. To determine changes in ECD practitioners' knowledge and perceptions of hearing in children pre- and post-training.

2. To determine generalisation of changes in ECD practitioners' knowledge and perceptions of hearing in children six-months post-training.

2.2 ETHICAL CONSIDERATIONS

The retrospective analysis of data yielded no direct ethical considerations from the principal researcher for this study. The larger project received ethical clearance with Prof De Wet Swanepoel as the primary investigator (GW20170922HS) (Appendix A). This study protocol received institutional ethical approval from the Faculty of Humanities research ethics committee of the University of Pretoria (HUM044/0621) (Appendix B). A mixed method was incorporated to analyse quantitative data retrospectively and qualitative data prospectively. A retrospective research design was utilised as data collection for the larger study started in June 2019. A prospective data component was incorporated in terms of a six-months post-training survey. The current study reported only on collected data from June 2020 to July 2021 to determine changes in ECD practitioner knowledge and perceptions of hearing in children pre- and post-training. The data analysis process only commenced after ethical approval was received (Appendix B). The 3E project and associates were responsible for the administration and collection of all training and documentation and obtaining informed consent. The

10

current researcher received written permission from the 3E project coordinators to gain access to their collected anonymised data from the 3E project for statistical analysis (Appendix C).

Ethical considerations will be discussed to protect the rights and welfare of the participants in the study during and after data is collected along with aligning the ethical obligations of the researcher (Leedy et al., 2020). The following ethical considerations were adhered to:

Informed consent

During the data collection process, participants received an initial phone call during which they were informed about what the research study would entail, and what is expected from research participants (Appendix D). Participants were given a choice to either participate or not to participate in the study. It was made clear that if they agree to participate in the study, they had the right to withdraw from the study at any moment, without any negative consequences. Participants were informed that participation in the study was completely voluntary, and that their personal information will be kept safe and will not be shared with any other organisation, thereby adhering to The Protection of Personal Information Act (POPI Act). The 3E coordinators observed electronic consent from participants by having participants digitally ticking the box on the online consent form (Appendix E) or agreeing on the WhatsApp permission section (Appendix F), thereby granting electronic permission that they understood the nature of the study along with the nature of participating in the study.

The 3E Project took the diversity of the South African population into account and the different languages accompanying each diverse group. It is important that the participants understood the information they received in the informed consent form and in the training to fully comprehend the information for personal understanding and application of it. The 3E coordinators was readily available to provide direct telephonic translation of the informed consent to ECD practitioners on request.

Protection from harm

Participating in the project did not increase the possible risk of normal day-to-day living of the participant. In receiving the training and/or completing the surveys, the participants were not subjected to any physical, mental, or emotional neglect nor caused any intentional stress, or embarrassment that may have affected their self-esteem.

Benefits

Participants were informed that there was no direct benefit by partaking in this study, yet after completing the full requirements of the nature of their participation, they will be placed in a lucky draw, to be one of ten participants to receive a monetary incentive from the 3E Project. This incentive and the needed requirements to qualify were clearly stated in the initial message from the 3E representative (Appendix F). With the additional data point added to the initial study, the eligible participants were informed that a second lucky draw was in place where one in five participants could receive an additional monetary incentive from the 3E Project (Appendix H).

Respect of confidentiality and privacy

The 3E project and its representatives respected the participants' privacy and kept all identifying personal information confidential. Confidentiality was ensured, by allocating a unique arbitrary code to participants, which was used on their digital documentation for the duration of the study. With permission from the 3E representatives (Appendix C), the researcher for this study, received anonymised data via an online google excel sheet.

Plagiarism

The study and written report were the researcher's original work. The researcher used the APA 7th edition referencing style to acknowledge accurate references of the sources used in this study.

Storage of data

The data and information obtained in the study will be stored electronically for 15 years at the Department of Speech-Language Pathology and Audiology and the University of Pretoria Research Data Repository (Figshare).

Release of information

The information obtained in the study was released to the public in the form of a published research article. The implications of sharing information are to improve health care and generate or broaden scientific knowledge. The release of information might help to plan services more effectively, advocate for better awareness regarding hearing health in children, better use of health care resources, development of more evidence-based interventions and consequently leading to better care for patients. The released information may generate the need and/or require more science and in turn widen the range of the research topic and promote better science. In essence, the shared data needs hold true to ethical considerations which are, privacy and confidentiality of participant information, valid consent, non-related issues to social justice nor having negative implications to public trust.

2.3 RESEARCH DESIGN

The study employed a pre-post training intervention design which investigated the effect of the educational training programme (the intervention) on the knowledge and perceptions of the ECD practitioners of hearing health in children before and after an mHealth training intervention programme was provided. Thus, employed an experimental one-group pre-and post-test design with a primary quantitative descriptive study design and a secondary qualitative component. The one-group pre- and post-test design consisted of a single group of participants that underwent a pre-experimental evaluation, then exposed to the intervention and thereafter, re-evaluated (Leedy et al., 2020). The investigation determined the extent to which evidence supported a claim about the training programme

and its effect on the knowledge and perceptions of ECD practitioners, making internal validity an important aspect of the design (Leedy et al., 2020).

As a retrospective study, anonymised data was utilised from a community-based hearing and vision screening programme for children in partnership with hearX Foundation and the Carel du Toit centre and Trust. A retrospective research design uses existing data that has been collected prior to the start of a study by starting with an effect and working backward to determine associations with the effect (Brink et al., 2018).

An additional data point was implemented as a six-month post-training follow-up survey to evaluate generalisation of changes in ECD practitioners' knowledge and perceptions of hearing in children six-months post intervention. By making use of a six-month post-training follow-up survey, generalisability could be evaluated by means of a naturalistic approach, by having the participants apply their newly obtained knowledge in a real world setting for six months. Thereafter answering the questions in the survey with broader applicability in context and having first-hand experience regarding the topics in the intervention. The study utilised the collected data within the longitudinal six-month period after the post-training survey.

2.4 RESEARCH PARTICIPANTS AND SELECTION CRITERIA

Convenience sampling was used to collect data from participants in this study. The number of participants involved between selected data points totalled to 1012 participants irrespective of the pre-training and post-training survey. For part of the secondary objective of study, participants were included within the longitudinal six-months period from July 2021 - January 2022.

For the study the umbrella term "ECD practitioners" constituted the following positions, working as either a principal, teacher, assistant, volunteer, administrator, mentor, or field worker. The ECD practitioners included were across the Western Cape and neighbouring communities as part of the 3E

community project. The participants comprised adult male and female practitioners aged 18 years and older.

The participants had to meet the following inclusion requirements for the initial study:

- They had to be working at an ECD centre.

- They had to be working with young children between birth and age six years.

- They had to be living in the Western Cape or neighbouring communities.

- They had to understand English.

To be eligible for the six-months follow-up survey the participants had to meet the requirements mentioned above, and the following:

- Completed the online community-based mHealth training programme.

- Completed both the pre-and post-training surveys online with six months passed.

2.5 RESEARCH MATERIAL AND APRRATUS

Training materials were available in English (Appendix I). It was agreed upon by the 3E project coordinators and representatives that English will be used in the training materials as it is an acceptable language of communication in South Africa (Gordon & Harvey, 2019).

2.5.1 Training material

The 3E Project made use of the EARS' training programme for teachers (Appendix I) by the hearX Foundation, Carel du Toit Centre & Trust, and the University of Pretoria. The 3E project and associates were responsible for the design and outlay of training images and recording of the voice notes used in training. The EARS stand for – Early, Academics, Red flags, and Support. Each of these sections were covered on a specific day and was the main topic of that day and in conclusion pertained to hearing loss, early identification, and intervention for children with hearing loss. The training days were as follow:

Introduction to 'EARS' training programme

- **Training day 1: 'E' for Early**

  This covered the importance of early identification of hearing problems and early intervention.

- **Training day 2: 'A' for Academics**

  This covered the influence of what hearing problems can have on academics, along with the importance of healthy hearing for healthy learning.

- **Training day 3: 'R' for Red Flags**

  This covered possible red flags to look out for and how this can be indicative of hearing problems in children.

- **Training day 4: 'S' for Support**

  This covered the ways in which the teachers/CHWs can support children with potential or diagnosed hearing problems.

Readability consensus for training material

A readability consensus was also applied to evaluate the readability of the information provided in the initial study. The information was processed through seven readability formulas (Flesch Reading Ease score, Gunning Fog, Flesch–Kincaid Grade Level, The Coleman–Liau Index, The SMOG Index, Automated Readability Index, and Linsear Write Formula). This measures and scores the text in the training material to find the average grade level, reading age, and text difficulty. This was done to ensure that participants were able to read and fully comprehend the text and information. The readability checker, an online text analysis system, analysed the text and calculated the number of sentences, words, syllables, and characters in the text. Thereafter the system connects this information to seven popular readability formulas and gives a score to determine if the text would be readable to the audience.

The readability formulas and scores were as follow for Section A of the training material (Appendix I):

Table 1: Readability of training information.

Readability formula	Score	Readability
Flesch Reading Ease score	7	Fairly easy to read
Gunning Fog	7	Fairly easy to read
Flesch-Kincaid Grade Level	6	Sixth grade level
The Coleman-Liau Index	8	Eighth grade level
The SMOG Index	5	Fifth grade level
Automated Readability Index	6	Fifth and sixth grade level
Linsear Write Formula	6	Sixth grade level
READABILITY CONSENSUS	6	Fairly easy to read Fifth and sixth grade level

The conclusion for the readability of training information came to a grade five to six reading level, which is classified as fairly easy to read.

2.5.2 Data collection material

ECD practitioners' knowledge and perceptions regarding hearing in ECD and hearing-related problems in children were surveyed pre-training (Appendix F a& J), directly post training (Appendix K & L), and six months post training (Appendix H). The survey was adapted based on work from van Wyk and colleagues (2018). All three surveys consisted of the same 12 closed-ended items (Table 2) pertaining to the learning objectives specified for the training material. In addition to these 12 items, the post-training survey (Appendix K & L) also included two additional closed-ended 5-point Likert scale items allowing participants to rate the training received. The 6-month post-training survey (Appendix H) included one additional closed-ended 5-point Likert scale item and an open-ended feedback question probing participants' practical application of the training information.

Moreover, the 6-month post-training survey (Appendix H) also evaluated the generalization of the training programme after 6 months. The surveys were compiled in English and made available in two

17

formats: an online Google form (sent as a WhatsApp link) or a WhatsApp message. Participants who indicated to their 3E representative that they could not access the Google form due to limited available mobile data received the survey in a WhatsApp message format.

Table 2: Survey on ECD practitioners' knowledge and perceptions of hearing related ECD in young children.

Pre-training survey[1, 2]
1. ECD staff and teachers know enough about hearing and hearing problems in children.
2. A child can be born with hearing problem.
3. There are different types of hearing problems.
4. Ear infections can cause hearing problems.
5. It is important to know if a child has hearing problems at an early age to help them.
6. Hearing problems in young children cannot be treated.[3]
7. There are signs in a child's behavior that may tell you if the child has a hearing problem.
8. Hearing problems can make learning to read and write difficult.
9. Hearing problems can make concentration in a classroom difficult.
10. Even with treatment children with hearing loss cannot achieve the same as other children in school.[3]
11. If someone thinks a child has a hearing problem the child should be sent to an audiologist.
12. A child with a hearing problem can hear better in school if they sit in the front row of the classroom.
Post-training survey [1, 4]
13. The information provided during the training programme was meaningful to me.
14. The training programme improved my knowledge on hearing problems in young children.
Six-month post-training survey [1, 5]
15. After completing the EARS training, I am more aware of hearing problems in children than before.
16. Can you tell us of any way that you have used the information you received during the EARS Training?

[1] Response categories ranged from (1) strongly disagree, (2) disagree, (3) neutral, (4) agree, (5) strongly agree. [2] 12 Likert scale Items used to determine ECD practitioners' knowledge scores. [3] Likert scale score reversed due to negatively stated item. [4] Contained the 12 Likert scale items with 2 additional closed-ended Likert scale items. [5] Contained the 12 Likert scale items along with 2 closed-ended Likert scale items from post-training survey, 1 additional closed-ended Likert scale item and an open-ended question.

2.6 DATA COLLECTION PROCEDURES

2.6.1 Introduction to EARS training programme

Participants were included in the 3E Project based on their involvement at ECD centres across the Western Cape and neighbouring communities. The principal of each ECD centre was contacted telephonically by a 3E project representative and introduced to the EARS training programme (Appendix D). The introduction included information about the 3E Project and what services they were offering the communities. The introduction also included that participants will be required to answer

18

some questions before and after training. After the introduction was made, the principal could accept or decline to have his/her teachers be part of the programme.

Upon accepting to have their ECD centre participate in the project, the principals were required to speak to their ECD practitioners and inform them of the EARS training programme and all ethical disclosures. The ECD practitioners could accept or decline to participate in the training programme. The principals were asked to send a list of his/her practitioners' contact details, which were kept confidential and were only shared with the 3E project representatives. ECD practitioners were contacted, by the 3E representative allocated to a specific district part of the town and were introduced to the programme and received a telephonic explanation (Appendix D) of the 3E project. After the project was explained, the ECD practitioners could again accept or decline to participate in the project. Upon accepting the ECD practitioners received additional information telephonically of the training programme and what to expect of the next four days of training (Appendix D).

The Google forms online service (Country version: South Africa, with the latest update March 31, 2020) was utilised to create two online surveys (Appendix J & K). The WhatsApp application (version 2.21.11) was utilised to create two interactable WhatsApp messages (Appendix F & L) as supplementary duplicates of the original online surveys, as some participants made use of WhatsApp specific data bundles and could not access the online version of the survey. The WhatsApp version of the survey had clear instructions along with steps for participants to follow before they completed the survey.

Depending on participants' choice of receiving the survey, participants were divided into those participants receiving the online surveys, and those receiving the WhatsApp format of the surveys. The only difference between the two groups was the format in which they received it. Yet, the information and questions were identical in both the formats of the surveys.

19

2.6.2 Pre-training survey

Before participants started with training, they received a WhatsApp message (Appendix G) requesting them to click on a link, contained in the message, that would direct them to the online pre-training survey (Appendix J). Along with the initial message, each participant received an image as a quick three-step summary of how they will go about before answering the questions on the survey (Appendix M). The online pre-training survey (Appendix J) consisted of a study information section, an informed consent section, a participant information section, and a question-item section. The informed consent section had a link that directed them to the full detailed informed consent letter (Appendix E) which they were requested to read at their own discretion. After reading the informed consent letter, participants were obligated to electronically tick the online consent section, marking it as signed, implying that they read and understood the informed consent form, thus giving consent. Participants then moved on to the participant information section where they had to fill in necessary personal information regarding date of birth (DOB), participant number, which was allocated to them by a 3E representative, their home language, gender, and their involvement in an ECD centre. After completion, participants moved on to the question-item section, which included 12 items which they rated on a 5-point Likert scale (1) strongly disagree, (2) disagree, (3) neutral, (4) agree, (5) strongly agree.

Simultaneously with the online pre-training survey (Appendix J), the WhatsApp pre-training survey (Appendix F) was sent to participants who requested to receive this format. This format included all the same information, yet the participants received well-instructed information imbedded in the survey regarding how to complete the WhatsApp format of the survey.

After completing the surveys, participants submitted their forms online by selecting "submit" on the online version, and with the participants which completed the WhatsApp format had to send their completed survey to their allocated 3E representative. Thereafter the participant was informed that they should await further instructions for the training programme. The answered surveys were later sent, after ethical clearance was obtained, to the first author to accomplish the research objectives of

20

this study. The anonymised retrospective data was in a excel spreadsheet that contains the online and WhatsApp survey responses to each survey section.

2.6.3 Training programme and post-training survey

The hearX Foundation along with the implementation partner, Carel du Toit Centre and Trust, were entrusted with the planning, design, and recording of the training materials in the form a voice note. The training material set out for each day had specific objectives in place with conceivable learner outcomes. Training materials were made available to participants in the form of a voice note. This approach was utilised with exceptional care being taken, as in-person training was prohibited due to the COVID-19 pandemic that had just ensued and a nationwide lockdown was put in place. Daily images (Appendix N), pertaining to the day's topic, accompanied the voice note sent to participants to aid their training and understanding of the topic. The training concluded with the participant receiving a voice note and a picture over WhatsApp pertaining specifically to the allocated topic of the day, for example, Day 1 – Early. Participants could listen to the voice notes as many times as preferred along with viewing the picture.

After completion of the four-day training programme, all participants received a congratulatory message (Appendix O) for completing the training programme and were notified to complete the post-training survey by either a link to the online google form (Appendix K) or the WhatsApp message (Appendix L) containing the post-survey. After the participants completed the post-training survey, they were congratulated on completing the training programme and both surveys and were sent their certificate of completion (Appendix P).

2.6.4 Six-months post-training survey

An additional data point was implemented in the form of a six-month follow-up survey (Appendix H). To be eligible for this survey the participants were required to have completed both the pre-training survey (Appendix F & J), the community-based training programme, and post-training survey

21

(Appendix K & L) and a total of six-months that has passed since they've completed the online post-training survey (Appendix H).

The same 3E representatives allocated to the specific community at the start of the study sent out a WhatsApp message (Appendix H) informing the participant about the six-month follow-up survey.

The six-month post-training follow-up survey (Appendix H) was administered after six months, which served as a measure of generalisability of the information obtained during the training period. This survey did not serve as a test. The participants were informed that after completion of the post-training follow-up survey they will be included in the lucky draw to be one in five participants to receive an incentive from the hearX Foundation.

2.7 DATA PROCESSING AND ANALYSIS

Raw data were captured on a google drive Excel spreadsheet in a binary format by the 3E representatives. The data were extracted from this cloud-based server by the primary investigator for the study with permission from the 3E coordinator (Appendix C).

2.7.1 Quantitative Analysis

Data was analysed using the Statistical Package for the Social Sciences (SPSS) version 27 (International Business Machines (IBM) Corp, 2020), except for the power analysis that was conducted using G*Power version 3.1.9.4 (Faul et al., 2016). For the achieved power analysis, a conservative approach was used where the smallest sample sizes were used because the larger the sample size, the higher the power. For all power analyses, a medium to large effect was considered (Cohen, 1969), and a .05 level of significance was used. For the Kruskal-Wallis (*KW*) test, an achieved power of 0.851 was attained for the smallest pairwise comparison between the unrelated groups *degree in education and ECD level 6* and *ECD level 1 to 3* groups (sample sizes $n_1 = 33$ and $n_2 = 35$). This figure indicated that the statistical test (*KW*) is 85.1% strong and when comparing larger samples sizes, a more powerful

22

analysis was obtained which yields higher statistical values. For the Wilcoxon signed-rank (*WSR*) test, an achieved power of 1.000 was attained for the smallest comparison between related groups, which included the six months post-training group (*n*=232). Inferential statistical analysis was used to determine the strength and relationship between variables and observed change.

Descriptive statistical measures were used to quantitively analyse demographic information of the study sample, along with determining the mean and standard deviations of the knowledge scores for each survey, respectively. A higher knowledge score (5) indicated better knowledge, and a lower score (1) indicated poorer knowledge. For the continuous variables, normality was tested using the Shapiro-Wilk test, and since all the *P*-values were less than .05, the data differed significantly from normality (Field, 2005). Accordingly, nonparametric methods were used. Inferential statistics included conducting the *KW* test to determine whether there were significant differences in survey scores between different independent variable groups, language, position at the ECD centre, and level of training. If a statistical significance (*P*<.05) was found between the categories of a variable, a subsequent post hoc pairwise comparison was performed using Dunn (1964) procedure. The Mann-Whitney U test was run to determine if there were differences in ECD participant who have been previously exposed to screening procedures and who was not. Distributions of the engagement scores for the two groups were not similar (Previously exposed = 580) and (Not previously exposed = 432), as inspection of descriptive statistics. Stepwise linear regression models were built with predictors, participant age (continuous variable), previously exposed to screening procedures (binary variable with "*no*" as benchmark), participant home language (3 categories with *English* as benchmark), level of training (4 categories with *no formal training and other* as benchmark) and the position at an ECD centre (three categories with *assistant/volunteer* as benchmark). For the regression models, the recommendation of at least ten observations per predictor was met (Austin and Steyerberg, 2015), assuring that the regression models were statistically powerful.

2.7.2 Qualitative Analysis

The open-ended question in the post-training survey conducted six months later was analysed qualitatively using content analysis. Six months after the training, participants' experiences and application of the EARS training information were investigated using a direct content analysis methodology and open-ended question probing. The content analysis entailed categorising statements into meaningful units that collectively described the statements of participants and represented ideas or topics of interest. Categorisation was completed by organising the data into main categories with subcategories and tabulating the frequency distributions.

CHAPTER 3

RESEARCH ARTICLE

mHealth-Supported Hearing Health Training for Early Childhood Development Practitioners: An Intervention Study

Authors: Divan du Plessis, Faheema Mahomed-Asmail, Talita le Roux, Marien Alet Graham, Tersia de Kock, Jeannie van der Linde and De Wet Swanepoel

3.1 Abstract

(1) Hearing health training and promotion is a priority for early childhood development (ECD) practitioners, but training opportunities are limited, especially in low- and middle-income countries (LMIC). mHealth (mobile health) has the potential to deliver scalable ear and hearing training to ECD practitioners. (2) This study investigated the effect of an mHealth training intervention program for ECD practitioners to improve knowledge and perceptions of hearing health in young children. An experimental one-group, pre-post-test study included ECD practitioners working with children between birth and 6 years old across 31 neighbouring communities in the Western Cape Province, South Africa. Hearing health training was provided using WhatsApp messages that encompassed infographics and voice notes.

Knowledge and perceptions regarding hearing and hearing-related problems in children were surveyed pre-training, directly post training, and 6 months post training. (3) ECD practitioners ($N = 1012$) between 17 and 71 years of age received the mHealth training program and completed both the pre-and post-training surveys. Overall, knowledge scores indicated a significant improvement from pre- to post training ($Z = -22.49$; $p < 0.001$). Six-month post-training knowledge scores were sustained. Content analysis of ECD practitioners' application of the training information 6 months post training indicated improved awareness, practical application, better assistance for hearing problems, and widespread advocacy. (4) The mHealth training program supports improved knowledge and perceptions of ECD practitioners regarding hearing health for young children. With improved knowledge scores maintained 6 months post training, mHealth hearing health training is an effective intervention. An mHealth training program for ECD practitioners provides a scalable, low-cost intervention for primary and secondary prevention in childhood hearing loss, especially in LMICs.

Keywords: mHealth; community-based; telecare; hearing health; education and training; early childhood development; intervention

3.2 Introduction
3.2.1 Hearing Loss and Early Childhood Development

Hearing loss (HL) is one of the most prevalent developmental disorders, with 34 million children estimated to have disabling HL globally, of which 95% reside in low- and middle-income countries (LMIC) [1–4]. Hearing loss identification in young children is delayed typically due to absent screening programs, with late identification having far-reaching consequences [4–6], including listening and communication difficulties, delays in speech and language development, delayed cognitive development, poor academic achievement, and adverse effects on social and emotional well-being [4,5,7–12]. Furthermore, an estimated 60% of childhood hearing loss [3] is preventable through the implementation of public health

26

measures, including immunization, adequate maternal and childcare practices, early identification, and management of common ear conditions through systematic screenings [3]. Therefore, early detection of childhood HL is the key to effective management to support optimal outcomes [1,3,13].

Early childhood development (ECD) programs aim to provide services for optimal childhood development while ensuring general health. ECD centres, particularly in LMICs and low-socioeconomic-status (SES) communities, serve as front-line healthcare platforms for early detection, with ECD practitioners often acting as primary caregivers [14,15]. Therefore, ECD practitioners play a critical role in preventing and detecting developmental risks in young children, including hearing loss [14,16]. A study by Abraham and colleagues [17] investigated the feasibility of training teachers at day-care centres regarding primary ear care and observed an increase in average knowledge scores from 28.4% pre-training to 86% post training. The training was provided through in-person teaching methods, which included lectures, discussions, role-plays, clinical examinations, and practice sessions [17]. Scalable interventions for hearing health education and promotion could leverage innovative approaches such as mHealth (mobile health) to make ear and hearing health training for ECD practitioners more accessible. mHealth refers to the utilization of mobile phones, wireless devices, and digital assistants to improve healthcare delivery [18,19]. With the implementation of mHealth, barriers, including limited availability of hearing health professionals, transportation, time, expenses, and resource availability, can be addressed [20]. Utilizing mHealth to educate and promote hearing health can enhance the capabilities of ECD practitioners to substantially reduce the morbidity related to ear and health disorders [21,22].

3.2.2 mHealth Intervention Solutions

Innovative mHealth approaches are rapidly becoming important for public health care in LMICs, providing tools for awareness, health promotion campaigns, and services that are accessible and can scale rapidly [20,23–28]. In addition, the ubiquity of mobile phones and increased internet access have created an opportunity to optimize the implementation of mHealth services and potentially increase the efficiency of various service-delivery cadres [18,19,24]. mHealth applications have been adopted across multiple professions and adapted for the intent of use in clinical and non-clinical environments [29,30]. Text-message interventions' significant benefits include reminders, alerts, education, motivation, and prevention [29,31]. Individualized motivating SMS text messages or reminders are one example of how digitization allows health promotion and preventive interventions to be customized and tailored to the requirements of people [32].

Hearing health training and promotion through mHealth has the potential to support preventative hearing healthcare services for young children from underserved populations, but there is a lack of evidence on hearing health promotion through mHealth [20,32]. A recent scoping review by Frisby and colleagues [18] on mHealth and hearing loss identified only three papers reporting hearing health promotion, all published recently in 2021. Employing mHealth to train personnel such as ECD practitioners who serve as front-line workers in vulnerable communities can promote and support primary and secondary prevention of childhood hearing loss. However, limited evidence exists regarding the effectiveness of mHealth training interventions for ECD practitioners on hearing health in young children [28]. Therefore, this study investigated the effect of an mHealth training program on ECD practitioners' knowledge and perceptions of hearing in young children.

3.3 Materials and Methods

3.3.1 Study Design

An experimental one-group, pre-post-test design was employed to determine the effect of an mHealth-supported intervention program on ECD practitioners' knowledge and perceptions of hearing health in children immediately after training and 6 months post training. In addition, a secondary qualitative component reported how ECD practitioners used the training information during a 6-month interval since completing the training.

3.3.2 Recruitment of participants

The project included ECD centres and schools of low SES across 31 neighbouring communities in Cape Town and Paarl Valley within the Western Cape Province. ECD centres and schools included community-based facilities that provided education and nurturing care to children from birth to 6 years of age. ECD centres and schools were selected based on previous hearing screening services provided by the hearX Foundation and Carel du Toit Centre and Trust. Additionally, new ECD centres and schools were identified and approached, and a referral-based method was utilized allowing participating ECD practitioners to refer new practitioners. The principals of selected ECD centres and schools were contacted to obtain the contact details of willing participants. Participants included ECD practitioners working with young children between birth and 6 years of age at ECD centres and schools. For this study, the term *ECD practitioners* was used to encompass various positions at an ECD centre or school, including principals, teachers, assistants, volunteers, administrators, mentors, or field workers. ECD centres and schools essentially provide similar services ensuring quality early-childhood development, with teachers and professionals receiving equivalent ECD training (Multimedia Supplementary S1).

29

Inclusion criteria for participants included self-reported proficiency in English and access to WhatsApp and mobile data on their phones. Participants also had different levels of educational training in terms of ECD levels (Multimedia Supplementary S1). Participants were contacted telephonically by representatives of the *3E project* (Ears and Eyes for Education) facilitated by local Non-Governmental Organizations (NGOs) (hearX Foundation and Carel du Toit Centre and Trust) in the selected communities within the Western Cape Province. The *3E project* representatives were lay community health workers trained in providing hearing screenings. The *3E project* representatives were allocated to the specific district parts of the selected communities and assigned to remotely communicate and facilitate training to the ECD practitioners for the specific ECD centres over WhatsApp. Several ECD centres were previously involved in school hearing screening services provided by the hearX Foundation prior to the commencement of this study. This paper reports data from participants who received ear and hearing health training through the mHealth training program between June 2020 and July 2021.

3.3.1 mHealth Hearing Training Program

The training program's goal was to equip ECD practitioners with the necessary knowledge and practical application of information to actively participate in the process of identifying and supporting children with potential hearing difficulties and where necessary make appropriate referrals. The *3E project* used the EARS (Early, Academics, Red flags, and Support) training program (Multimedia Supplementary S2) for ECD practitioners to achieve its goal. The training program guided ECD practitioners through critical concepts related to hearing loss in young children during the developmental ECD period, the importance of healthy hearing for healthy learning, and appropriate risks that warrant a referral.

3.3.1.1 Development of mHealth Training Material

Training material was developed through a collaborative initiative by the hearX Foundation, Carel du Toit Centre and Trust with the University of Pretoria. The four-day training material consisted of a daily pre-recorded voice note accompanied by an infographic (Multimedia Supplementary S2) pertaining to each day's ascribed topic (e.g., day 1–early). Each day's voice note included detailed educational information focusing on theoretical content and practical application that ECD practitioners could apply in and outside ECD centres or schools. The accompanied infographic concisely displayed the most important information from the daily voice note. The voice note and infographic were in English and designed specifically for distribution over WhatsApp via instant messages. A readability consensus was applied to evaluate the readability of the information provided over the four-day training program. The information was processed through seven readability formulas (Flesch Reading Ease score, Gunning Fog, Flesch–Kincaid Grade Level, The Coleman–Liau Index, The SMOG Index, Automated Readability Index, and Linsear Write Formula), and the readability consensus score was at fifth- to sixth-grade reading level, which is classified as fairly easy to read. The infographic provided ECD practitioners with a concise display of important information on that day's topic with the intent to listen to the voice note while viewing the infographic simultaneously. The content for each day's training covered essential intervention aspects and learning objectives relating to healthy hearing in young children (Table 3) and the importance of early identification of a hearing problem by observing a child's behaviour and possible red flags relating to a hearing problem. Additionally, it covered how a hearing problem can affect a child's academic achievement if the necessary support is not received.

Table 3: Training description and learning objectives with survey items.

Training Components	Learning Objectives	Items from Survey [1,2] (Multimedia Supplementary S3)

Part 1—"E" for Early Importance of early identification of hearing problems and early intervention. *Duration [3]: 2 min, 12 s*	To understand the importance of identifying a hearing problem as soon as possible in children. To understand the importance of ear health in children.	Items 2, 5, and 6
Part 2—"A" for Academics Influence of hearing problems on academic performance and importance of healthy hearing for healthy learning. *Duration [3]: 2 min, 35 s*	To describe why healthy hearing is important for healthy learning. To understand how and why hearing problems result in poor school progress.	Items 8, 9, and 10
Part 3—"R" for Red Flags Possible red flags to look out for and how this can be indicative of hearing problems in children. *Duration [3]: 2 min, 40 s*	To describe the different types of hearing problems. To understand and identify the red flags (warning signs) of hearing problems in children.	Items 3, 4, and 7
Part 4—"S" for Support Ways teachers can support children with potential or diagnosed hearing problems. *Duration [3]: 2 min, 50 s*	To understand the referral process of a child with hearing problems to an audiologist. To understand how to support the child with a hearing problem in the classroom.	Items 6, 10, 11, and 12

[1] 5-point Likert scale used: (1) strongly disagree, (2) disagree, (3) neutral, (4) agree, and (5) strongly agree. [2] Twelve items linked to the EARS training content that were used to determine knowledge scores. [3] Duration of the daily voice note.

3.3.1.2 Presentation of Training Material

All communications, training, and feedback were conducted via WhatsApp (version 2.21.11). Participants were telephonically introduced to the program on a Friday, and upon acceptance to participate, they received a detailed explanation of the program and the pre-training survey. Training days only occurred on weekdays, which totalled four days of training. Participants were informed that training would commence on a Monday. After receiving the participants' completed pre-training survey, the allocated 3E representatives sent the respective voice note and daily infographic over the four remaining training days. Participants could listen to the voice notes as often as they preferred while viewing the infographic. The voice notes and daily infographics are stored in the WhatsApp chat between the 3E representative and ECD

32

practitioner even after the completion of the training program. After completing the training program, participants received a certificate of completion via WhatsApp.

3.3.1.3 Data Collection Material

ECD practitioners' knowledge and perceptions regarding hearing in ECD and hearing-related problems in children were surveyed pre-training, directly post training, and 6 months post training. The survey was adapted based on work from van Wyk and colleagues [33]. All three surveys consisted of the same 12 closed-ended items (Multimedia Supplementary S3) pertaining to the learning objectives specified for the training material. Participants were asked to rate each of the 12 items on a 5-point Likert scale ranging from (1) strongly disagree to (5) strongly agree. Participants' scores were summed from the 12 survey items, and a knowledge score was obtained per participant and as a collective group. The knowledge scores were utilized to compare the changes in scores over the three surveys. In addition to these 12 items, the post-training survey also included two additional closed-ended 5-point Likert scale items allowing participants to rate the training received. The 6-month post-training survey included one additional closed-ended 5-point Likert scale item and an open-ended feedback question probing participants' practical application of the training information.

Moreover, the 6-month post-training survey also evaluated the generalization of the training program after 6 months. The surveys were compiled in English and made available in two formats: an online Google form (sent as a WhatsApp link) or a WhatsApp message. Participants who indicated to their 3E representative that they could not access the Google form due to limited available mobile data received the survey in a WhatsApp message format.

3.4 Procedures

The principal of each ECD centre or school was contacted telephonically, received all ethical disclosures, and was introduced to the EARS training program. Principals could accept or reject on behalf of their ECD centre or school to partake in the EARS training program. Principals were requested to speak to their staff and obtain permission to share the contact details of those interested in participating in the training program. On condition of acceptance, ECD practitioners were contacted telephonically by the 3E representatives, introduced to the EARS' training program, and invited to participate. The telephonic explanation included what the EARS training program entailed and the topic of *the importance of healthy ears and hearing for healthy learning*, along with what participants could expect over the four days after accepting to participate in the program. The ECD practitioners were informed that they would receive a certificate of completion after the EARS training program and completed three surveys. ECD practitioners would also be placed into a lucky draw to be 1 of 10 participants to receive a monetary incentive, including a voucher of ZAR 250 (USD 17.50) at specified supermarkets. Before the ECD practitioners started training, they either received a WhatsApp message from the 3E representative with a link directing them to the online pre-training survey or a WhatsApp message containing the survey itself. ECD practitioners received a participation number for all documentation purposes and were required to use the same participant number throughout the training program.

Each day, participants received the mHealth training material through WhatsApp. After completing the four-day training program, all participants received a congratulatory message for completing the program and were notified to complete the post-training survey by either a link to the online Google form or the WhatsApp message containing the post-training survey.

34

A WhatsApp message informed participants about the 6-month post-training survey. Participants willing to complete the 6-month post-training survey were included in another lucky draw to be one of five participants to receive a monetary incentive, including a voucher of ZAR 350 (USD 23.50) at specified supermarkets. Data collection procedures linked to the mHealth training program are outlined in Figure 1.

mHealth training program	Data collection	Participants
Pre training (June 2020) ☐ Introduction to training program ☐ Received pre-training survey link or WhatsApp message	**Quantitative component** **Pre-training survey** 12 Likert scale items (knowledge score)	1012 ECD practitioners
Training (June 2020 – July 2021) ☐ 4-day WhatsApp-based training program ○ Daily voice note ○ Daily infographic		
Post training (June 2020 – July 2021) ☐ Received post-training survey link or WhatsApp message	**Quantitative component** **Post-training survey** 12 Likert scale items (knowledge score) 2 Likert scale items (training experiences)	1012 ECD practitioners
6-month post training (January 2021 – February 2022) ☐ Notified of 6-month post-training survey via WhatsApp ☐ Received survey via a WhatsApp message	**Quantitative and Qualitative component** **6-month post-training survey** 12 Likert scale items (knowledge score) 3 Likert scale items (training experiences) 1 open-ended question	232 ECD practitioners

Figure 1. Data collection procedures linked to the mHealth training program.

3.5 Statistical Analysis

3.5.1 Quantitative Analysis

Data were analysed using the Statistical Package for the Social Sciences (SPSS) version 27 (International Business Machines (IBM) Corp, 2020) except for the power analysis, which was conducted using G*Power version 3.1.9.4 [34]. For the achieved power analysis, a conservative approach was used where the smallest sample sizes were used. Accordingly, for the Kruskal–

Wallis (H) test and for the Wilcoxon signed-rank (Z) tests, which determine whether differences between unrelated and related groups are statistically significant, respectively, the 6-month post-training group ($n = 232$) was used, and for the Kruskal–Wallis post hoc test, the smallest sample sizes concerning pairwise comparison was used (*degree in education and ECD level 6* ($n_1 = 33$) and *ECD level 1 to 3* ($n_2 = 35$)). For Spearman correlations (r_s), used to test relationships between variables, the 6-month post-training group ($n = 232$) was used. For all power analyses, a medium to large effect was considered [35], and a 0.05 level of significance was used. For these tests, Kruskal–Wallis, Kruskal–Wallis post hoc, the Wilcoxon signed-rank test and the Spearman correlation, the achieved power was 0.864, 0.851, 1.000 and 1.000, respectively, indicating that these tests are 86.4%, 85.1%, 100.0% and 100.0% strong, and when comparing larger samples sizes, a more powerful analysis was obtained, which yields higher statistical values. Inferential statistical analysis was used to determine the strength and relationship between variables and observed change.

Descriptive statistical measures were used to quantitively analyse demographic information of the study sample along with determining the mean and standard deviations of the knowledge scores for each survey, respectively. A higher knowledge score (5) indicated better knowledge, and a lower score (1) indicated poorer knowledge. For the continuous variables, normality was tested using the Shapiro–Wilk test, and since all the p-values were less than 0.05, the data differed significantly from normality [36]. Accordingly, nonparametric methods were used. Inferential statistics included conducting the Kruskal–Wallis test to determine whether there were significant differences in survey scores between different independent variable groups, language, position at the ECD centre, and level of training. If a statistical significance ($p < 0.05$) was found between the categories of a variable, a subsequent post hoc pairwise comparison was performed using Dunn (1964) procedure. Spearman correlations was used to

test for associations between variables. Stepwise linear regression models were built with predictors, participant age (continuous variable), previously exposed to screening procedures (binary variable with "*no*" as benchmark), participant home language (three categories with *English* as benchmark), level of training (four categories with *no formal training and other* as benchmark), and the position at an ECD centre (three categories with *assistant/volunteer* as benchmark). For the regression models, the recommendation of at least ten observations per predictor was met [37], assuring that the regression models were statistically powerful.

3.5.2 Qualitative Analysis

The open-ended question in the 6-month post-training survey was qualitatively analysed using content analysis. A direct content analysis approach was followed by utilizing an open-ended question probing to investigate participants' experiences and application of the EARS training information 6 months after the training. The content analysis involved categorizing statements into meaningful units that collectively described participants' statements, representing ideas or topics of interest. Categorization concluded with organization into main categories with sub-categories along with the frequency distributions in a tabulated format.

3.6 Results
3.6.1 Demographic Characteristics of Study Sample

A total of 1012 ECD practitioners between 17 and 71 years of age (mean 37.67, SD 10.78) were included in the pre- and post-training of the study, and 232 of those between 19 and 65 years of age (mean 36.97, SD 10.49) also completed the 6-month post-training survey (Table 4).

Table 4: Demographic characteristics of participants completing the pre-training, post-training (n = 1012), and 6-month post-training (n = 232) survey.

	Pre- and Post-Training Survey (*n* = 1012)	Six-Month Post-Training Survey (*n* = 232)
	n (%)	*n* (%)
Gender		
Female	958 (94.7)	222 (95.7)
Male	54 (5.3)	10 (4.3)
Home language		
isiXhosa	571 (56.4)	135 (58.2)
English	221 (21.8)	44 (19.0)
Afrikaans	209 (20.7)	52 (22.4)
Other	11 (1.1)	1 (0.4)
Position at ECD centre or school		
Principal	219 (21.6)	53 (22.8)
Teacher	607 (60.0)	128 (55.2)
Assistant or Volunteer	186 (18.4)	51 (22.0)
Level of training		
Education degree (B.Ed.) and ECD level 6	159 (15.7)	33 (14.2)
ECD level 4 and 5	537 (53.1)	125 (53.9)
ECD level 1 to 3	130 (12.8)	35 (15.1)
No formal training and other	186 (18.4)	39 (16.8)
Previous exposure to hearing screening		
Yes	580 (57.3)	140 (60.4)
No	432 (42.7)	92 (39.7)

3.6.2 Pre-Training Knowledge Scores

Table 5 provides a summary of the pre-and post-training knowledge scores. There was a significant difference across the average overall pre-training knowledge score for different languages ($H(2) = 94.79$, $p < 0.001$) and levels of training groups ($H(3) = 48.54$, $p < 0.001$). Note that, for language, for all inferential statistics, the category "*other*" was not considered, as it only applied to 1.1% of the participants. For the language groups, post hoc analysis indicated that both *English* (mean 4.01, SD 0.36) and *Afrikaans* (mean 4.01, SD 0.34) groups scored significantly higher than the *isiXhosa* group (mean 3.74, SD 0.44). The level of the training groups' post hoc analysis revealed significant differences in pre-training scores between all levels of training except between the *no formal training and other* and *degree in education and ECD level 6*. ECD practitioners with *no formal training and other* drew attention upon analysis because the group had significantly higher pre-training knowledge scores (mean

3.94, SD 0.38) compared to ECD practitioners with *ECD level 1 to 3* (mean 3.71, SD 0.49) and

ECD level 4 to 5 educational training (mean 3.81, SD 0.43).

Table 5: Descriptive statistics, the z-test statistic and the corresponding p-values of the pre-post test scores of ECD practitioners (n = 1012).

Survey Items	Pre-Training Mean Score (SD) [1]	Post-Training Mean Score (SD) [1]	Mean Improvement (SD)	Z	*p*-Value
1. ECD staff and teachers know enough about hearing and hearing problems in children.	2.77 (1.06)	3.43 (1.26)	0.66 (1.39)	−13.81	<0.001
2. A child can be born with hearing problem.	4.15 (0.64)	4.53 (0.58)	0.38 (0.79)	−14.27	<0.001
3. There are different types of hearing problems.	3.89 (0.85)	4.50 (0.61)	0.61 (0.90)	−18.26	<0.001
4. Ear infections can cause hearing problems.	4.04 (0.74)	4.60 (0.57)	0.56 (0.86)	−17.57	<0.001
5. It is important to know if a child has hearing problems at an early age to help them.	4.37 (0.67)	4.71 (0.52)	0.34 (0.75)	−13.51	<0.001
6. Hearing problems in young children cannot be treated. [2]	3.56 (1.00)	4.05 (1.04)	0.49 (1.33)	−11.14	<0.001
7. There are signs in a child's behaviour that may tell you if the child has a hearing problem.	4.10 (0.68)	4.58 (0.57)	0.48 (0.82)	−16.20	<0.001
8. Hearing problems can make learning to read and write difficult.	3.99 (0.84)	4.50 (0.72)	0.51 (0.87)	−16.20	<0.001
9. Hearing problems can make concentration in a classroom difficult.	4.24 (0.62)	4.58 (0.62)	0.34 (0.78)	−13.04	<0.001
10. Even with treatment, children with hearing loss cannot achieve the same as other children in school. [2]	3.16 (1.10)	3.58 (1.30)	0.42 (1.40)	−8.83	<0.001
11. If someone thinks a child has a hearing problem, the child should be sent to an audiologist.	4.14 (0.61)	4.61 (0.56)	0.47 (0.71)	−17.84	<0.001
12. A child with a hearing problem can hear better in school if they sit in the front row of the classroom.	3.83 (0.83)	4.38 (0.82)	0.55 (0.97)	−16.01	<0.001
Overall mean	3.85 (0.43)	4.34 (0.41)	0.48 (0.54)	−22.49	<0.001
Total	46.25 (5.12)	52.04 (4.91)	5.79 (6.48)		

[1] Likert response category ranged from (1) strongly disagree, (2) disagree, (3) neutral, (4) agree, and (5) strongly agree. [2] Likert scale score inverted based on negative stated item.

A stepwise linear regression model (Table 6) was statistically significant (F [6, 994] = 27.69, $p < 0.001$), and predictors explained 14.3% of the variation in overall pre-training survey scores. Older participants ($\beta = 0.05$, $p = 0.001$) and previous exposure to hearing screenings (β

= 1.20, $p < 0.001$) significantly contributed to higher pre-training scores (Table 5). For the latter, participants exposed to hearing screenings had a significantly higher overall knowledge score than participants who were not exposed to hearing screenings previously. Four predictors were associated with significantly lower pre-training knowledge scores (Table 5), namely *isiXhosa* as a home language ($\beta = -3.31$, $p < 0.001$) when benchmarked against *English*, *ECD training levels 1 to 3* ($\beta = -2.19$, $p < 0.001$) and *ECD training levels 4 and 5* ($\beta = -1.19$, $p < 0.001$) when benchmarked against *no formal training or other*, and participants who are *principals* ($\beta = -0.89$, $p = 0.03$) when benchmarked against *assistants/volunteers*.

Table 6: Linear regression analysis results for pre-training and improvement knowledge scores.

Model	$R^{2\,1}$	Unstandardised Coefficients		Standardised Coefficients	T	p-Value	95.0% Confidence Interval for β	
		$\beta^{\,2}$	Std. Error	β			Lower Bound	Upper Bound
Pre-training	0.143	46.59	0.63		73.68	<0.001	45.35	47.83
Age		0.05	0.02	0.11	3.33	0.001	0.02	0.08
Previously exposed to screening procedures		1.20	0.33	0.12	3.68	<0.001	0.56	1.84
Home language—isiXhosa		−3.31	0.33	−0.32	−9.89	<0.001	−3.96	−2.65
Level of training—ECD level 1 to 3		−2.19	0.51	−0.14	−4.35	<0.001	−3.18	−1.20
Level of training—ECD level 4 and 5		−1.90	0.34	−0.12	−3.45	<0.001	−1.87	−0.51
Participants' work position—Principal		−0.89	0.42	−0.07	−2.14	0.03	−1.71	−0.08
Improvement knowledge scores	0.071	7.47	0.79		9.41	<.001	5.91	9.03
Age		−0.10	0.02	−0.16	−4.71	<.001	−0.14	−0.06
Home language—isiXhosa		2.82	0.40	0.22	7.06	<.001	2.04	3.61
Participants' work position—Principal		1.69	0.54	0.11	3.16	0.002	0.64	2.74

[1] Determination coefficient for proportion of variance in the knowledge scores (dependent variable) predicted by the independent variables. [2] Effect on the overall knowledge score (dependent variable) per model.

3.6.3 Post-Training Knowledge Scores

The post-training mean score was significantly ($Z = -22.49$, $p < 0.001$) higher than the pre-training mean score across each of the 12 survey items (Multimedia Supplementary S3; $p < 0.001$; Table 5). Increasing age was negatively associated with the overall improvement in post-training knowledge scores ($r_s = -0.11$, $p < 0.001$). Language groups demonstrated significantly different overall improvements from pre- to post-training scores ($H(2) = 44.89$, $p < 0.001$). Participants speaking *isiXhosa* had the highest mean improvement of (mean 0.59, SD 0.60) from the pre- to the post-training survey, and participants speaking *Afrikaans* had the lowest mean improvement score of (mean 0.32, SD 0.38). Post hoc tests revealed significant pairwise differences between all pairwise language comparisons except between the *English* and *Afrikaans* groups for improvement scores, indicating that the two groups had similar improvement knowledge scores after the training.

Level of training demonstrated different overall improvements from pre- to post-training scores ($H(3) = 12.98$, $p = 0.005$). Participants with *ECD training levels 1 to 3* had the highest mean improvement score (mean 0.55, SD 0.60), while participants with *no formal training and other* had the lowest mean improvement knowledge score of (mean 0.38, SD 0.47). Post hoc testing revealed significant pairwise differences between *degree in education and ECD level 6* (mean 0.40, SD 0.52) and *ECD level 4 and 5* (mean 0.52, SD 0.55), between *no formal training and other* (mean 0.38, SD 0.47) and *ECD levels 1 to 3* (mean 0.55, SD 0.60), and between *no formal training and other* (mean 0.38, SD 0.47) and *ECD level 4 and 5* (mean 0.52, SD 0.55). With the *ECD levels 1 to 3* participants showing the highest improvement, it can be argued that this group could have felt that the training would be beneficial for them and put in their best efforts to learn from the training, which clearly paid off.

A stepwise linear regression model (Table 6) on predictors for improvement in knowledge scores significantly explained 7.1% of the variation (F [3, 997] = 25.52, $p < 0.001$). Participants' home language and position at ECD centres or schools significantly contributed to improved knowledge scores. For the latter, participants in the *principal* position had a significant improvement ($\beta = 1.69$, $p = 0.002$) in their overall knowledge scores when compared to participants in the *assistant/volunteer* position (Table 6). For the former, participants with *isiXhosa* as a home language showed a significant increase ($\beta = 2.82$, $p < 0.001$) in their overall improvement knowledge scores when compared to participants with *English* as a home language (Table 6). Participant age was significantly associated ($\beta = -0.10$, $p < 0.001$) with mean improvement scores in that for every one year older, the score decreased by 0.10 on average.

In addition to the 12 items in the post-training survey, participants were asked if the information provided during the training program was meaningful. The majority of participants (770/1012, 76.1%) either strongly agreed or agreed (227/1012, 22.4%) that the training was meaningful to them. Additionally, participants were asked whether the training increased their knowledge of hearing problems in young children. Most participants (750/1012, 74.1%) strongly agreed that the training increased their knowledge, while others (250/1012, 24.7%) agreed.

3.6.4 Six-Month Post-Training Knowledge Scores

The 6-month post-training mean knowledge score (mean 4.38, SD 0.35) was significantly higher than the pre-training mean knowledge score ($Z = -11.36$, $p < 0.001$) but did not differ significantly from the post-training mean knowledge score ($Z = -0.45$, $p = 0.65$). Based on the Wilcoxon signed-rank test, across all 12 items, there were no significant differences between the post-training knowledge scores and 6-month post-training knowledge scores except for

item 1 ($Z = -2.47$, $p = 0.01$) and item 11 ($Z = -2.04$, $p = 0.04$). There was a significant mean difference in knowledge scores between the three participant position groups at ECD centres ($H(2) = 11.09$, $p = 0.004$), with the *assistant/volunteer* group having the highest mean score of (mean 4.48, SD 0.33) and the *principals* having the lowest mean score of (mean 4.26, SD 0.33). A post hoc test revealed significant pairwise differences between all pairwise comparison position groups except between *teachers* and *assistants/volunteers*.

3.6.5 Six-Month Post-Training Content Analysis

Table 7 provides the categories and sub-categories identified for 181 ECD practitioners' responses to the open-ended question in the 6-month post-training survey. The question prompted ECD practitioners to indicate any way that they used the information received during the EARS training program during the 6-month interval since completing the online training.

Table 7: Application of the EARS training information reported 6-month post training by ECD practitioners and analysed qualitatively (n = 181).

Categories	Sub-Categories	Illustrative Responses from ECD Practitioners
Identifying hearing problems in children (*n* = 77)	Notice and refer children with hearing problems	*"I have identified many children in my school and community, it helps a lot."* *"The training helped me because there is one child that I was suspecting, and it turns out that I was right."* *"Refer children who I suspect that they have hearing problem to audiologists where they get checked".*
	More observant and aware of hearing problems	*"I've learned a lot because I can see if the child is not hearing before someone's tells me."* *"Yes, it helped me out a lot and now I know how to identify or see a child who can't hear properly."* *"I started to observe my children to see if anyone of them has a hearing problem."* *"I start looking at behaviours of children to see if I pick up any signs that they might have a hearing problem."*
Sharing information (*n* = 50)	Share information with colleagues	*"I have shared the important information with the ECD teachers whom I am working with in the playgroup sessions."* *"Shared my knowledge with my ECD principals."* *"I have printed out all the slides and put it in a file and I have made copies and shared the information with colleagues and primary school teachers."*
	Share information with parents	*"I gained lots of knowledge of hearing problems in children and share it with the parents and the community and they must look out for symptoms in the child and what to do if the has a hearing problem and where to go."* *"I address the information in our parents WhatsApp group."*
	Share information with community members	*"I educate the community about the hearing loss in children."* *"I managed to share the whole information with the community and my neighbours."*

43

Apply information in the classroom setting (n = 27)	*"I was more aware and could adapt my lessons and assessments to meet children's needs."* *"I am always watching in the classroom if every child is in the right place that he/she can hear me."* *"I now look at the children when I'm teaching, and let them seat in front row, so that they can read my lips. I always use different learning styles—visual learning style to accommodate children who cannot hear."* *"I will let her sit in front and make sure I position myself in the ear that she can hear me from…"*
Assisting children with hearing problems (n = 21)	*"I am more informed now and will be able to take care of a child with any hearing problems."* *"Strategies to help her was put in place, she's doing very well with eye contact and in her academics."* *"I am going more down to the child's level to look straight in the face when I'm talking to the child."*
Assist and advise parents of children with hearing problems (n = 6)	*"I can… advise parents better regarding certain problems their child has."* *"I can… provide parents with needed help."* *"I can also advise a parent what to do with the child and the best way to handle the problem and where to take the child who have ear infections/problem."*

3.7 Discussion

The mHealth hearing training program improved ECD practitioners' knowledge scores significantly, with improvements maintained at 6 months post training. Almost all (997/1012, 98.5%) of the ECD practitioners experienced the training to be meaningful and reported improved knowledge of hearing health in young children. A concise multimedia mHealth hearing training program is a low-cost, scalable intervention to equip ECD practitioners with knowledge to identify and refer at-risk children, and to support children with hearing difficulties in the class environment.

ECD practitioners with the highest level of training (*degree in education and ECD level 6*) had significantly higher pre-training knowledge scores than practitioners with the lowest level of training (*ECD level 1 to 3*). Those ECD practitioners with the lowest level of training demonstrated the largest improvement in post-training scores. Improved knowledge scores confirm that the mHealth training program provided meaningful educational information and that the training successfully met learning objectives on hearing health in young children (Table 3). ECD practitioners' knowledge is crucial for inclusive ECD classes, where exceptional teaching and caring practices are necessary for the holistic development of vulnerable children

44

[14,38]. With the widespread diversity and background of children in ECD centres and schools, especially in LMICs, teachers and ECD practitioners need specialised knowledge competencies and skills to provide nurturing care and an auspicious learning environment for children with special needs [38].

ECD practitioners' demographic characteristics had varying effects on their pre-training knowledge scores. Significantly higher pre-training knowledge scores were evident for ECD practitioners previously exposed to hearing screenings in their facilities. This emphasises an important additional benefit of hearing screening in ECD centres and schools, resulting in improved general knowledge of hearing health in children. Home language and English proficiency were also important with *isiXhosa*-home-language ECD practitioners having lower knowledge scores in the pre-training survey when compared to ECD practitioners with *English* as their home language. Interestingly, ECD practitioners speaking *isiXhosa* showed the highest mean knowledge improvement in the post-training survey. The information provided in the voice notes and daily images were fairly easy to understand, with readability consensus at a fifth- to sixth-grade reading level ensuring accessibility of the content. The 6-month post-training knowledge scores remained consistent, demonstrating that the level of information furthermore supported long-term retention. Future training should, however, be explored in versions that support different home languages to facilitate wider accessibility.

Additional improvements in post-training knowledge were related to age and position in ECD centres and schools. Linear regression indicated that ECD practitioners working as a *principal* at an ECD centre or school had a lower knowledge score in the pre-training survey when compared to *assistants/volunteers*. Younger ECD practitioners are typically perceived as knowledge receivers [39]. A study by Burmeister and colleagues [39] investigated the effect of

age on the knowledge transfer process, indicating younger participants were more able and motivated than older participants to receive knowledge in the knowledge transfer process. Therefore, younger participants seemed to assimilate the educational material with greater ease leading to higher improvement scores. Campbell-Barr [40] stated that ECD knowledge encompasses more than just theoretical knowledge. The Bernstein model on knowledge acquisition through practice acknowledged that professionals in early development, such as ECD practitioners, utilize both theoretical and practical knowledge [40]. Therefore, practical experience is an important factor that influences the knowledge of ECD practitioners, as was also observed with higher pre-training knowledge scores for ECD facilitators with prior hearing screening exposure. It is likely that *principals* at the ECD centres or schools are less involved in everyday classroom activities and educational settings, which could have contributed to lower pre-training knowledge scores. The *principals* did, however, demonstrate significant improvements in post-training knowledge scores.

Content analysis analysed the ways in which ECD practitioners used the training material after 6 months post mHealth training. The analysis identified various categories and sub-categories, including improved awareness, practical application, better assistance for hearing problems, and widespread advocacy. Two prominent categories included *identifying hearing problems in children* and *sharing information*. Almost half (77/181, 42.5%) of the ECD practitioners reported *identifying hearing problems* better, and in the sub-category (51/77, 66.2%) of the ECD practitioners reported being *more observant and aware of hearing problems* (Table 7). More than a quarter (50/181, 27.6%) of ECD practitioners indicated they shared the training information with colleagues, parents, and community members. The training improved ECD practitioners' competence and supported confidence in approaching young children with hearing problems and applying training information in the classroom setting. For example, one

ECD practitioner indicated they *will be able to take care of a child with any hearing problems*, and another practitioner mentioned that they *could adapt lessons and assessments to meet children's needs*.

The mHealth training program for ECD practitioners provides a scalable, low-cost training for primary and secondary prevention of childhood hearing loss, especially in low-and middle-income countries and communities of low SES. Furthermore, the provision of training material via an instant-messaging application has important advantages, including cost-effective administration of an intervention program, efficient management, and easy distribution across geographic boundaries [28,41,42]. This study was the first of its kind to evaluate the use of an mHealth training program to support knowledge and awareness of hearing health [20]. An important strength of this study was its ecological validity, with broad inclusion criteria representative of community ECD centres and schools in low-income settings.

Further investigation warrants implementing culturally tailored resources and mHealth intervention and training for ECD practitioners in their home languages. Moreover, evaluation of the impact of an mHealth training program on the identification of children with hearing problems could be investigated.

Study Limitations

The study had a large sample size (*n* = 1012), with participants in both the pre- and post-surveys. However, a limitation of this study was a low response rate for the 6-month follow-up survey, with approximately only one-quarter (232/1012, 22.9%) of the participants from the original sample completing the follow-up survey. The low response rate may partly have been due to survey fatigue [43]. Participants used their mobile phones and cellular data to complete the mobile-based survey. The cost of cellular data could have prohibited participants from

47

accessing the WhatsApp-based survey. Additionally, participants may have changed mobile numbers during the 6-month interval and therefore did not receive the 6-month follow-up survey. Furthermore, large sample sizes like those in this study can result in detection of small effect sizes with high power. This means a result may be flagged as statistically significant when it does not have real-world significance [44]. While this may be a potential limitation of this study, the consistent pattern of significant improvement across all pre- and post-questions and no significant differences between immediate post and 6-month post questions suggest that this was not the case.

3.8 Conclusions

ECD practitioners' knowledge and perceptions regarding hearing health in young children are critical for primary and secondary prevention in childhood hearing loss, especially in countries with low SES, where ECD facilities may serve as the initial point of contact for hearing screening. An mHealth intervention program can support improved knowledge and perceptions of ECD practitioners regarding hearing health for young children, with generalization maintained over time. Employing an mHealth training program provides a scalable, low-cost intervention for prevention in childhood hearing loss, especially in low- and middle-income countries.

3.9 Supplementary Materials

The following supporting information can be downloaded at: www.mdpi.com/xxx/s1.

3.10 Funding

3.11 Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by The Research Ethics Committee of the University of Pretoria (HUM044/0621) on 29 July 2021.

3.12 Informed Consent Statement

Informed consent was obtained from all subjects involved in the study

3.13 Data Availability Statement

The authors can be contacted to access the data.

3.14 Acknowledgments

The contents of this work are solely the responsibility of the authors and do not necessarily represent the official views of the supporting organizations. The authors would like to acknowledge and thank the hearX Foundation and Carel du Toit Centre and Trust for their outstanding support and management of the data collection process as well as all participants involved within this study.

3.15 Conflicts of Interest

The authors declare no conflict of interest.

3.16 References

1. Eksteen, S.; Launer, S.; Kuper, H.; Eikelboom, R.H.; Bastawrous, A.; Swanepoel, D.W. Hearing and vision screening for preschool children using mobile technology, South Africa. *Bull. World Health Organ.* **2019**, *97*, 672–680. https://doi.org/10.2471/BLT.18.227876.

2. Olusanya, B.O.; Newton, V.E. Global burden of childhood hearing impairment and disease control priorities for developing countries. *Lancet.* **2007**, *369*, 1314–1317. https://doi.org/10.1016/S0140-6736(07)60602-3.

3. World Health Organization. Deafness and Hearing Loss. Who.int. 2021. Available online: https://www.who.int/news-room/fact-sheets/detail/deafness-and-hearing-loss (accessed on 14 December 2021).

4. Chadha, S.; Kamenov, K.; Cieza, A. The world report on hearing, 2021. *Bull. World Health Organ*. **2021**, *99*, 242–242A. https://doi.org/10.2471/BLT.21.285643.

5. GBD. Hearing Loss Collaborators. Hearing loss prevalence and years lived with disability, 1990–2019: Findings from the Global Burden of Disease Study 2019. *Lancet* **2021**, *397*, 996–1009. https://doi.org/10.1016/S0140-6736(21)00516-X.

6. Yousuf Hussein, S.; Swanepoel, D.W.; Biagio de Jager, L.; Mahomed-Asmail, F. Knowledge and attitudes of early childhood development practitioners towards hearing health in poor communities. *Int. J. Pediatr. Otorhinolaryngol.* **2018**, *106*, 16–20. https://doi.org/10.1016/j.ijporl.2017.12.026.

7. Ching, T.Y.; Leigh, G.; Dillon, H. Introduction to the longitudinal outcomes of children with hearing impairment (LOCHI) study: Background, design, sample characteristics. *Int. J. Audiol.* **2013**, *52*, (Suppl. 2), S4–S9. https://doi.org/10.3109/14992027.2013.866342. PMID: 24350694; PMCID: PMC7279706.

8. Cole, E.B.; Flexer, C. *Children with Hearing Loss: Developing Listening and Talking, Birth to Six*, 4th ed.; Plural Publishing Inc.: San Diego, CA, USA, 2020; Volume 53.

9. Graham, P.J.; Shuler-Krause, E. Building Strong Foundations for Educational Achievement: Language Assessments in Early Childhood Education for Deaf and Hard of Hearing Children. Psychology in the Schools. Available online: https://onlinelibrary.wiley.com/doi/epdf/10.1002/pits.22333 (accessed on 13 April 2020).

10. Robertson, C.M.; Howarth, T.M.; Bork, D.L.; Dinu, I.A. Permanent bilateral sensory and neural hearing loss of children after neonatal intensive care because of extreme prematurity: A thirty-year study. *Pediatrics.* **2009**, *123*, e797–e807. https://doi.org/10.1542/peds.2008-2531.

11. World Health Organization. Primary Ear and Hearing Care Training Resource. 2006. Available online: https://www.who.int/pbd/deafness/activities/hearing_care/trainer.pdf?ua=1 (accessed on 14 December 2021).

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

13. Pimperton, H.; Blythe, H.; Kreppner, J.; Mahon, M.; Peacock, J.L.; Stevenson, J.; Terlektsi, E.; Worsfold, S.; Yuen, H.M.; Kennedy, C.R. The impact of universal newborn hearing screening on long-term literacy outcomes: A prospective cohort study. *Arch. Dis. Child.* **2016**, *101*, 9–15. https://doi.org/10.1136/archdischild-2014-307516.

14. Smit, N.A.; van der Linde, J.; Eccles, R.; Swanepoel, D.W.; Graham, M.A. Exploring the Knowledge and Needs of Early Childhood Development Practitioners from a Low-Resource Community. *Early Child Educ. J.* **2021**, *49*, 197–208. https://doi.org/10.1007/s10643-020-01063-3.

15. Yousuf Hussein, S.; Swanepoel, D.W.; Biagio de Jager, L.; Myburgh, H.C.; Eikelboom, R.H.; Hugo, J. Smartphone hearing screening in mHealth assisted community-based primary care. *J. Telemed. Telecare* **2016**, *22*, 405–412. https://doi.org/10.1177/1357633X15610721.

16. Lehmann, U.; Sanders, D. Community Health Workers. Available online: https://www.who.int/hrh/documents/community_health_workers.pdf (accessed on 24 August 2021)

17. Abraham, V.J.; Balraj, V.; Shankar, N.; Job, A.; Joseph, A. Training teachers of day care centres for primary ear care. *Trop. Doct.* **2003**, *33*, 98–100. https://doi.org/10.1177/004947550303300215.

18. Dugas, M.; Gao, G.G.; Agarwal, R. Unpacking mHealth interventions: A systematic review of behavior change techniques used in randomized controlled trials assessing mHealth effectiveness. *Digit Health* **2020**, *6*, 2055207620905411. https://doi.org/10.1177/2055207620905411.

19. Early, J.; Gonzalez, C.; Gordon-Dseagu, V.; Robles-Calderon, L. Use of Mobile Health (mHealth) Technologies and Interventions Among Community Health Workers Globally: A Scoping Review. *Health Promot. Pract*. **2019**, *20*, 805–817. https://doi.org/10.1177/1524839919855391.

20. Frisby, C.; Eikelboom, R.; Mahomed-Asmail, F.; Kuper, H.; Swanepoel, D.W.m-Health Applications for Hearing Loss: A Scoping Review. *Telemed. J. E Health* **2022**, *28*, 1090–1099. https://doi.org/10.1089/tmj.2021.0460.

21. Mantena, S.; Celi, L.A.; Keshavjee, S.; Beratarrechea, A. Improving community health-care screenings with smartphone-based AI technologies. *Lancet Digit Health* **2021**, *3*, e280–e282. https://doi.org/10.1016/S2589-7500(21)00054-6.

22. Dawood, N.; Mahomed Asmail, F.; Louw, C.; Swanepoel, D.W. Mhealth hearing screening for children by non-specialist health workers in communities. *Int. J. Audiol.* **2021**, *60* (Suppl. 1), S23–S29. https://doi.org/10.1080/14992027.2020.1829719.

23. Clark, J.L.; Swanepoel, D.W. Technology for hearing loss—As We Know it, and as We Dream it. *Disabil. Rehabil. Assist. Technol.* **2014**, *9*, 408–413. https://doi.org/10.3109/17483107.2014.905642. Epub 2014 Apr 8. PMID: 24712413.

24. Kazi, A.M.; Ahsan, N.; Jamal, S.; Khan, A.; Mughis, W.; Allana, R.; Kazi, A.N.; Kalimuddin, H.; Ali, S.A.; McKellin, W.; et al. Characteristics of mobile phone access and usage among caregivers in Pakistan—A mHealth survey of urban and rural population. *Int. J. Med. Inform.* **2021**, *156*, 104600. https://doi.org/10.1016/j.ijmedinf.2021.104600.

25. Mahomed-Asmail, F.; Swanepoel, D.W., Eikelboom, R.H.; Myburgh, H.C.; Hall, J., 3rd. Clinical Validity of hearScreen™ Smartphone Hearing Screening for School Children. *Ear Hear.* **2016**, *37*, e11–e17. https://doi.org/10.1097/AUD.0000000000000223.

26. Swanepoel, D.W.; Myburgh, H.C.; Howe, D.M.; Mahomed, F.; Eikelboom, R.H. Smartphone hearing screening with integrated quality control and data management. *Int. J. Audiol.* **2014**, *53*, 841–849. https://doi.org/10.3109/14992027.2014.920965.

27. Swanepoel, D.; Clark, J.L. Hearing healthcare in remote or resource-constrained environments. *J. Laryngol. Otol.* **2019**, *133*, 11–17. https://doi.org/10.1017/S0022215118001159.

28. Richardson, B.P.; van der Linde, J.; Pillay, B.; Swanepoel, D.W. Do text messages about health and development in young children affect caregiver behaviour and child outcomes? A systematic review. *Health Educ. J.* **2020**, *80*, 225–237. https://doi.org/10.1177/0017896920965992.

29. Ojo, A.I. mHealth Interventions in South Africa: A Review. SAGE Open **2018**, *8*, 2158244018767223. https://journals.sagepub.com/doi/full/10.1177/2158244018767223 (accessed on 13 September 2021).

30. van der Pol, N.; Ntinga, X.; Mkhize, M.; van Heerden, A. A Scoping Review of mHealth Use in South Africa. Development Southern Africa. 2021. Available online: https://www-tandfonline-com.uplib.idm.oclc.org/doi/pdf/10.1080/0376835X.2021.1904837 (accessed on 12 February 2022).

31. Marcolino, M.S.; Oliveira, J.A.Q.; D'Agostino, M.; Ribeiro, A.L.; Alkmim, M.B.M.; Novillo-Ortiz, D. The Impact of mHealth Interventions: Systematic Review of Systematic Reviews. *JMIR* **2018**, *6*, e23. https://doi.org/10.2196/mhealth.8873.

32. Stark, A.L.; Geukes, C.; Dockweiler, C. Digital Health Promotion and Prevention in Settings: Scoping Review. *J. Med. Internet Res*. **2022**, *24*, e21063. https://doi.org/10.2196/21063.

33. van Wyk, T.; Mahomed-Asmail, F.; Swanepoel, W. Supporting hearing health in vulnerable populations through community care workers using mHealth technologies. *Int. J. Audiol.* **2019**, *58*, 790–797. https://doi.org/10.1080/14992027.2019.1649478.

34. Faul, F.; Erdfelder, E.; Lang, A.G.; Buchner, A.G. *Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav. Res. Methods* **2007**, *39*, 175–191. https://doi.org/10.3758/bf03193146.

35. Cohen, J. *Statistical Power Analysis for the Behavioral Sciences*; Academic Press: Cambridge, MA, USA, 1969.

36. Field, A. Second Edition of the Discovering Statistics Using SPSS Second Edition. 2005. Available online: http://users.sussex.ac.uk/~andyf/dsusflyer.pdf (accessed on 23 August 2022).

37. Austin, P.C.; Steyerberg, E.W. The number of subjects per variable required in linear regression analyses. *J. Clin. Epidemiol.* **2015**, *68*, 627–636. https://doi.org/10.1016/j.jclinepi.2014.12.014.

38. Henry, C.; Namhla, S. Continuous professional development for inclusive ECD teachers in Chiredzi Zimbabwe: Challenges and opportunities. *Sci. Afr.* **2020**, *8*, e00270. https://doi.org/10.1016/j.sciaf.2020.e00270.

39. Burmeister, A.; Fasbender, U.; Deller, J. Being perceived as a knowledge sender or knowledge receiver: A multistudy investigation of the effect of age on knowledge transfer. *J. Occup. Organ Psychol.* **2018**, *91*, 518–545. https://www.researchgate.net/publication/323126757_Being_perceived_as_a_knowledge _sender_or_knknowled_receiver_A_multi-study_investigation_of_the_effect_of_age_on_knowledge_transfer (accessed on 20 March 2022).

40. Campbell-Barr, V. The silencing of the knowledge-base in early childhood education and care professionalism. *Int. J. Early Years Educ.* **2018**, *26*, 75–89. https://www.researchgate.net/publication/321829583_The_silencing_of_the_knowledge-base_in_early_childhood_education_and_care_professionalism (accessed on 19 August 2022).

41. Swanepoel, W. eHealth Technologies Enable more Accessible Hearing Care. *Semin. Hear* **2020**, *41*, 133–140. https://doi.org/10.1055/s-0040-1708510.

42. Rassi, C.; Gore-Langton, G.R.; Gidudu Walimbwa, B.; Strachan, C.E.; King, R.; Basharat, S.; Christiansen-Jucht, C.; Graham, K.; Gudoi, S.S. Improving health worker performance through text messaging: A mixed-methods evaluation of a pilot intervention designed to increase coverage of intermittent preventive treatment of malaria in pregnancy in West

Nile, Uganda. *PLoS ONE* **2018**, *13*, e0203554. https://doi.org/10.1371/journal.pone.0203554.

43. de Koning, R.; Egiz, A.; Kotecha, J.; Ciuculete, A.C.; Ooi, S.Z.Y.; Bankole, N.D.A.; Erhabor, J.; Higginbotham, G.; Khan, M.; Dalle, D.U.; et al. Survey Fatigue During the COVID-19 Pandemic: An Analysis of Neurosurgery Survey Response Rates. *Front. Surg.* **2021**, *8*, 690680. https://doi.org/10.3389/fsurg.2021.690680.

44. Sedgwick, P. Clinical significance versus statistical significance. *BMJ* **2014**, *348*, 2–4. https://doi.org/10.1136/bmj.g2130.

CHAPTER 4

DISCUSSION, CLINICAL IMPLICATIONS AND CONCLUSION

4.1 OVERVIEW OF FINDINGS

This study investigated the effect of an mHealth-supported training intervention programme on ECD practitioners' knowledge and perceptions of hearing health in children immediately after training and six months post-training. ECD practitioners' knowledge and perceptions ratings had a significant increase post-training and 6-months post-training. A qualitative component provided insight into ECD practitioners' perceptions of hearing health in children six-months post-training. Almost all (98.5%) of the ECD practitioners reported the training to be meaningful and that it improved their knowledge of hearing health in young children.

ECD practitioners' knowledge is crucial for inclusive ECD classes, where exceptional teaching and caring practices are necessary for the holistic development of vulnerable children (Henry & Namhla, 2020; Smit et al., 2021). With the widespread diversity and background of children in ECD centres and schools, especially in LMICs, teachers and ECD practitioners need specialised knowledge, competencies, and skills to provide nurturing care and an auspicious learning environment for children with special needs (Henry & Namhla, 2020). The concise multimedia mHealth hearing training programme investigated in this study can be used as a low-cost, scalable intervention to equip ECD practitioners with the knowledge to identify at-risk children and support children with hearing difficulties in the classroom setting.

4.1.1 Effect of prior exposure to hearing screening on knowledge scores

Baseline knowledge scores were determined by the pre-training survey that was utilised to identify ECD practitioners' pre-training knowledge regarding hearing health in young children.

57

ECD practitioners' demographic characteristics had varying effects on their pre-training knowledge scores. Significantly higher pre-training knowledge scores were evident for ECD practitioners previously exposed to hearing screenings in their facilities. This emphasises an important additional benefit of providing hearing screening in ECD centres and schools as it potentially results in improved general knowledge of hearing health in children. Chen et al. (2018) investigated the effect of prior knowledge on new factual information. Findings indicated that information related to prior knowledge could effectively be integrated into existing knowledge systems and could be remembered (Chen et al., 2018). Prior knowledge facilitates the assimilation of new information and the distinction of similar information allowing the encoding and consolidation of pertinent information (Chen et al., 2018). Furthermore, once the memory trace is stable, the effect of prior knowledge persists for an extended period for newly acquired information (Chen et al., 2018). Prior exposure benefited ECD practitioners' pre-training knowledge and improvement scores due to familiarisation with similar information obtained previously, which assisted with answering the initial survey items and lead to greater generalisation.

4.1.2 Effect of educational level on knowledge scores

ECD practitioners with the highest level of training (*degree in education and ECD level 6*) had significantly higher pre-training knowledge scores than practitioners with the lowest level of training (*ECD level 1 to 3*). ECD practitioners with the lowest level of training also demonstrated the largest improvement in post-training scores. Improved knowledge scores confirm that the mHealth training programme provided meaningful educational information and that the training successfully met the learning objectives (Table 3). Interestingly, ECD practitioners with *no formal training and other* had significantly better pre-training knowledge scores than the group of practitioners with *ECD level 1 to 5* educational training. The high pre-

training knowledge scores resulted in the *no formal training and other* group having the lowest improvement scores. The occurrence of the *no formal training and other* group having the lowest improvement knowledge scores, requires further investigation to substantiate these results by evaluating within-group demographics like practitioners' age, home language and the position at the ECD centre.

4.1.3 Effect of home language on knowledge scores

Further investigation between participants' home language and the level of ECD training indicated that more than a quarter (29.2%) of ECD practitioners with *no formal training and other training* had Afrikaans as a home language when compared to the practitioners with *ECD level 1 to 3* (10.9%) and *ECD level 4 & 5* (16.7%) educational training. The ECD practitioners with *no formal training and other* could have limited benefit from their home language to aid in better pre-training scores due to the training material and questionnaires being compiled in English. Increased language proficiency with English as a secondary language could have benefit to better pre-training knowledge scores for ECD practitioners with *no formal training and other trainin*g, yet this was undetermined.

ECD practitioners with *isiXhosa* as a home language also had lower knowledge scores in the pre-training survey when compared to ECD practitioners with *English* as their home language. Interestingly, ECD practitioners speaking *isiXhosa* showed the highest mean knowledge improvement in the post-training survey. ECD practitioners' home language is an important facet to consider for successful use of an mHealth training programme. According to sociocultural theory, language is the primary vehicle of thought and understanding, facilitating learning, comprehension, and development (Van der Merwe, 2020). The majority (56.4%) of ECD practitioners' home language was *isiXhosa* and this had significant effect on their

59

knowledge scores. ECD practitioners with *isiXhosa* as a home language had poorer knowledge scores in the pre-training survey when compared to the ECD practitioners with *English* as their home language. Interestingly, ECD practitioners speaking *isiXhosa* showed a significant improvement with the highest mean knowledge scores improvement in the post-training survey when compared to participant with English as their home language. This finding indicates an increased understanding of the information provided in the EARS' training programme post training. The information provided in the voice notes and daily images were fairly easy to understand with readability consensus at a fifth to sixth grade reading level ensuring accessibility of the content and form part of pedagogical content knowledge skills (Van der Merwe, 2020). The six-month post-training knowledge scores remained consistent, demonstrating that the level of information furthermore supported long-term retention. Furthermore, improved concept literacy with long-term retention of the training information was important for generalising intervention strategies for young children with hearing problems.

4.1.4 Effect of participant age and work position on knowledge scores

The effect of continuous biographical variables on knowledge scores were explored and indicated that ECD practitioners with *no formal training and other* were significantly younger than ECD practitioners with *ECD level 4 and 5* educational training. The latter was significantly older than ECD practitioners with *ECD level 1 to 3* educational training. ECD practitioners who were younger could have multiple factors contributing to their increased pre-training knowledge scores. A contributing factor could be that digital era holds many social media platforms and search engines making educational information widely available and easily more accessible.

Younger ECD practitioners are typically perceived as knowledge receivers (Burmeister et al., 2018). A study by Burmeister and colleagues (2018) investigated the effect of age on the knowledge transfer process, indicating younger participants were more able and motivated than older participants to receive knowledge in the knowledge transfer process. Therefore, younger participants seemed to assimilate the educational material with greater ease leading to higher improvement scores. Linear regression indicated that ECD practitioners working as a *principal* at an ECD centre or school had a lower knowledge score in the pre-training survey when compared to *assistants/volunteers*. Campbell-Barr (2017) states that ECD knowledge encompasses more than just theoretical knowledge. The Bernstein model on knowledge acquisition through practice acknowledged that professionals in early development, such as ECD practitioners, utilize both theoretical and practical knowledge (Campbell-Barr, 2017). Therefore, practical experience is an important factor that influences the knowledge of ECD practitioners as was also observed with higher pre-training knowledge scores for ECD facilitators with prior hearing screening exposure. It is likely that *principals* at the ECD centres or schools are less involved in everyday classroom activities and educational settings, which could have contributed to lower pre-training knowledge scores. The *principals* did, however, demonstrate significant improvements in post-training knowledge scores when compared to their pre-training knowledge scores. This could be due to increased opportunities for improvement in knowledge scores after receiving the educational training material on hearing health in young children.

4.1.5 Six-month post-training qualitative perspectives

Content analysis investigated the ways in which ECD practitioners used the training material after six months post mHealth training. Various categories and sub-categories were identified including improved awareness, practical application, better assistance for hearing problems and widespread advocacy. Two prominent categories were *identifying hearing problems in*

61

children and *sharing information*. Almost half (42.5%) of the ECD practitioners reported *identifying hearing problems* better and in the sub-category the ECD practitioners (66.2%) reported being *more observant and aware of hearing problems*. More than a quarter (27.6%) of ECD practitioners indicated they shared the training information with colleagues, parents and community members. The training improved ECD practitioners' competence and supported confidence in approaching young children with hearing problems and applying training information in the classroom setting. For example, one ECD practitioner indicated they "…*will be able to take care of a child with any hearing problems*", and another practitioner mentioned that they "…*could adapt lessons and assessments to meet children's needs*".

The content analysis provided insight as to whether the ECD practitioner can successfully apply what they have learned when they return to the workplace. The qualitative component drew on implementation science, which aims to facilitate the use of programmes, practices, and policies based on scientific evidence in routine care settings (Bauer & Kirchner, 2020). The study did not formally describe the inclusion of an implementation science framework, yet through the adoption, reach, implementation, and sustainment of effective mHealth interventions in LMIC setting, it increased the public health impact. Through incorporating methods of implementation science, it ensured that all individuals requiring hearing health care services could benefit from innovations and best practices. Thereby having ECD practitioners actively engaging with children in the school context in which the intervention was introduced, factors could be identified that may possibly affects the uptake of the training programme into routine use. Hence, the study could identify areas of interest which ECD practitioners highlighted from experience and apply implementation science to create better "real-world" applicable training programmes to increase the outcome of the training programme on ECD practitioners' knowledge and perceptions of hearing health in children.

4.2 CLINICAL IMPLICATIONS

In this study, the mHealth training programme for ECD practitioners provided a scalable, low-cost training for primary and secondary prevention of childhood hearing loss, especially in low-middle income countries and communities of low SES. Furthermore, the provision of training material via an instant messaging application has important advantages, including cost-effective administration of an intervention programme, efficient management, and easy distribution across geographic boundaries (Rassi et al., 2018; Richardson et al., 2020; Swanepoel, 2020)

The study highlighted the feasibility and effectiveness of an mHealth-supported training programme, and the sustainability and impact on ECD practitioners' knowledge post-training. The implementation of the mHealth training programme can be broadened and applied in other contexts such as with other health professionals, community workers, and lay-persons like parents and caretakers. Hence, mHealth training programmes could be made applicable not only for hearing health training, but also other educational areas as well. Adaptation of the training programme would require an evaluation to ensure the efficacy and effectiveness of the training programme (Bowen et al., 2010). This can be achieved by conducting a feasibility study through implementation science. By utilising implementation science to guide professionals in the process of training, a successful programme can be assembled to deliver high standard and effective training that can be individualised to the specific area in which a new training programme is needed.

4.2.1 Implementation considerations

Implementation science and clinical research share many characteristics and a rigorous methodology, yet clinical research focuses more on the effectiveness and efficacy of clinical

trials (Bauer & Kirchner, 2020; Rudd, Davis, & Beidas, 2020). Establishing the efficacy of innovation does not guarantee its widespread adoption in real-world practice. Implementation science focuses on increasing the use of evidence-based practices, and the impact on public health by identifying and addressing barriers and facilitators to the adoption of evidence-based clinical innovations (Bauer & Kirchner, 2020; Rudd et al., 2020).

Numerous evidence-based practices, programmes, and policies in audiology, specifically mHealth interventions, are not implemented on a large scale, and barriers to adoption, implementation, and maintenance limits their potential public health impact (Studts, 2022). Implementation science provides perspectives, frameworks, and methods that are highly relevant to the shared mission of audiology to provide the best possible hearing health care to all those who require it. By incorporating implementation science it places value on accessible service delivery, individualised, understandable, and cost-effective training based on evidence, quality, and research to contribute to the improvement of children's functioning and quality of life, as well as population hearing health.

Care must be taken to ensure that existing inequalities are not inadvertently exacerbated, and that those who benefit from improved implementation are representative of the full diversity of those who could and should benefit (Brownson et al., 2021). Similarly, from an organisational and service delivery standpoint, interventions and implementation strategies must be feasible, acceptable, and sustainable in communities and settings with limited resources and numerous barriers (Brownson et al., 2021).

With the overarching objective to increase the adoption and use of an mHealth intervention programme in routine, clinical practice, emphasis should be placed on the context in which the training programme will take place, the adaptation of the training programme, and equitable health services for all. The following topics are important considerations for the

64

implementation of an mHealth training programme and explains how the current study acknowledged the various components.

4.2.1.1 Context

The context in which implementation occurs is a fundamental consideration in implementation science (Rudd et al., 2020; Stensland et al., 2022). The mHealth training programme context was more than just the setting in which it was implemented (Bauer & Kirchner, 2020). The context can be divided into different ecological models highlighting multiple levels of influence on health and health behaviour, for example, individual, organisational or institutional, community and system/policy levels (Bauer & Kirchner, 2020).

Planning, implementing, and sustaining an mHealth training programme necessitate consideration of the dynamic influences of variables such as patient characteristics, leadership engagement, community norms, and health care policies (Bauer & Kirchner, 2020). A proposed framework (Figure 2) was drawn up to illustrate the different levels of consideration when implementing the EARS' training programme. The EARS training programme primarily focused on training ECD practitioners on hearing health in young children with the objective to increase practitioner knowledge on hearing loss and facilitate early identification and intervention services. Through primary prevention, ECD practitioners are introduced to the mHealth training programme, which focused on hearing health education. Hearing health incorporated early identification of hearing loss in children through identifying common red flags that might be indicative of a possible hearing loss. The health education was context-specific of a school or classroom setting. This would create specific, measurable, and realistic aims for ECD practitioners to focus on. The primary prevention led to secondary prevention

65

which focus on supporting children in need of hearing health professionals either at the local clinic or at an audiologist.
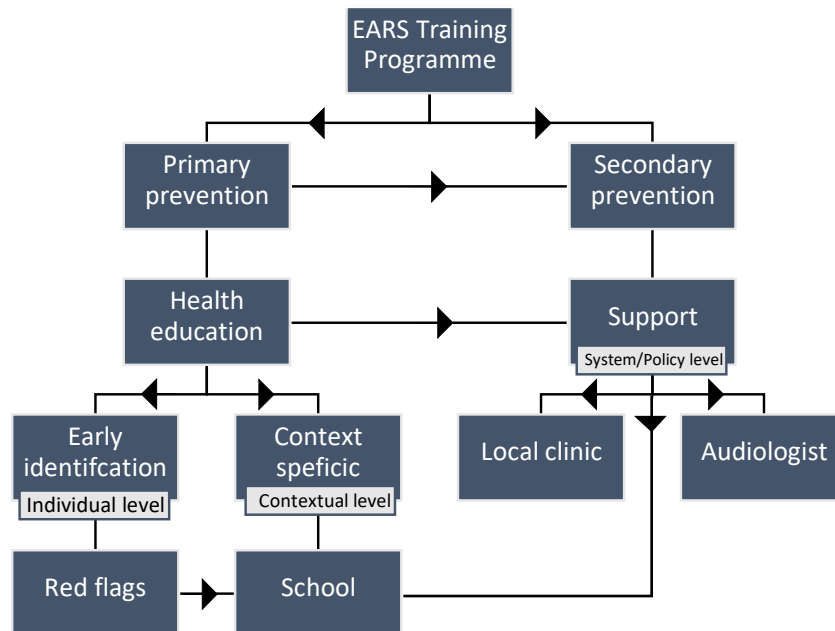
Figure 2. Different levels of consideration when implementing the EARS' training programme.

Implementation science was addressed on an individual level to facilitate early detection of hearing loss. This would make it possible to take into consideration the effects of hearing loss when ECD practitioners identify it at an earlier stage (Figure 2). In addition, considering implementation science on a contextual level necessitated incorporating the training program into different contexts, such as a classroom environment. It was important to take into account each level to identify and mitigate any barriers that might have hindered the effectiveness of the training programme, such as language barriers, as well highlighting the facilitators that helped increased participation and greater uptake of the educational training, such as previous exposure to hearing screening services (Bauer & Kirchner, 2020).

4.21.2 Adaptation

Adaptation of the training programme is an important aspect in which the conventional in-person training paradigm is adapted into an mHealth-supported training programme to proactively work towards an easy and effective method of training. The adaptation from in-person training to an mHealth-supported training can overcome barriers such as the cost of administration and traveling. For instance, in this current study, in-person training was modified to involve mHealth supported services in which ECD practitioners could be trained asynchronously. By adapting the mode of training delivery by utilising WhatsApp messenger, ECD practitioners could easily incorporate the training into their day-to-day life. This is an important consideration as the implementation of an intervention programme need to have the feasible capability to adapt and transform to facilitate quality services under any circumstances. Furthermore, the adaptation of the training programme based on continuous implementation feedback hold numerous benefits to improving programme. Factors such as ECD practitioners' feedback on the application and administration of the training material could lead to ongoing improvement in areas of need or further elaboration.

4.2.1.3 Health Equity

With events and movements highlighting the pervasive and destructive effects that marginalize populations, communities, and health conditions domestically and worldwide, implementation science researchers have elevated health equity as a prominent focus area (Brownson et al., 2021). The importance of recognising the impact of social determinants of community members is underscored by the identification of social, cultural, and community-level factors that either facilitated or hinder the efforts of ECD and ECD practitioners (Atashbahar et al., 2022). The objective of the EARS training programme was to provide training services to communities in low- to middle-income districts. The training programme facilitated access to

67

educational training by eliminating numerous obstacles, such as travel and in-person training expenses. In this study, acceptance of the intervention was high among ECD practitioners and varied between neighbouring communities. The EARS mHealth training programme could therefore be considered as an equitable hearing health care solution, providing high quality hearing health training to ECD practitioners to be incorporated in LMIC which are limited to hearing health care services. In the delivery of equitable hearing healthcare through teachers or ECD practitioners, it in-turn affects the efficiency of hearing health service delivery. Early hearing loss identification leads to earlier intervention which necessitates less intensive intervention or "catch-up" later, resulting in more efficient hearing healthcare systems overall and improved hearing rehabilitation and occupational trajectories (Neumann et al., 2022).

In conclusion, the importance of implementations science in line with the current study highlighted the considerations of how the mHealth training programme adapted to meet contextual barriers such as limited training personnel, cost of travelling and administration and proceeded to deliver equitable hearing health care training to ECD practitioners at ECD centres and schools.

4.3 CRITICIAL EVALUATION: STRENGHTS AND LIMITATIONS OF CURRENT STUDY

4.3.1   Strengths of study

The study followed a mixed-method design, combining the use of quantitative and qualitative data. The mixed-method design enriched the quality of the study findings by integrating the quantitative knowledge scores with the obtained qualitative feedback to conceptualise the areas of improvement and need for future research to increase validity and real-world application (Regnault et al., 2018). Utilising a mixed-method design to analyse ECD practitioners'

knowledge scores and feedback ensured scientific rigour as the study's objectives were measured by method-triangulating the quantitative and qualitative data over the course of the training programme (Regnault et al., 2018). The overall benefit ensures that the quantitative methods achieve objectivity, whereas qualitative methods augment quantitative data through elaboration, clarification, or validation of data. The integration of quantitative and qualitative approaches enabled a more comprehensive and synergistic utilisation of data to provide a better understanding of the research findings than either approach alone (Guetterman et al., 2015).

Meta-inference ensured interpretive consistency and credibility through integrating the inferences derived from cross-checking the qualitative content analysis and quantitative survey responses. The quantitative survey identified increased knowledge post training, whereby the qualitive question identified the different ways ECD practitioners applied the EARS training information. Corrigan and Onwuegbuzie (2020) state that representative meta-inferences of the sample ensure generalisability within the mixed-method design. Thus, we obtained broader meta-inferences regarding the application of the information obtained from the training programme in different environments. This would not have been identified through just the quantitative surveys.

An important strength of this study was its external validity, more specifically, ecological validity, which is the generalisability of study findings into real word settings (Andrade, 2018). The knowledge scores (mean 4.34, SD 0.41) were generalised to six months post training (mean 4.38, SD 0.35) with ECD practitioners applying the information obtained in classroom environments. The real-world application draws on the implementation science model in which the research was not only of statistical importance but had an effect on ECD practitioners' behaviour. This behaviour change is one of the overarching goals for mHealth applications and the usefulness in real world settings. The identification of how ECD practitioners applied the

training information in the classroom setting ensures increased awareness of hearing health in children, which in turn can decrease the percentage of children with a hearing problem and to seek promptly intervention.

Due to the diversity and training of the target population an essential factor to be considered was the readability of the training material. The training information was developed to be simple and easily comprehended by non-hearing health professionals. The readability consensus score was at a grade five to six reading level, which is classified as easy to read. Therefore, the level of the educational information was appropriate for learner objectives and considered a strength.

This study was the first of its kind to utilise an mHealth approach in providing educational information on hearing health to ECD practitioners in low SES communities. This allows for reproducibility into similar settings using the existing training model to train ECD practitioners on other topics of interest.

The study had a large sample size (N = 1012) which was favourable in determining an accurate mean value in participants' knowledge scores and identify any outliers in the data set. With a sample size being directly related to the statistic's *margin of error,* which is the accuracy of calculating the statistics, a large sample size gives a smaller margin of error (Zamboni, 2019).

4.3.2 Study limitations

A limitation of this study was the low response rate for the six-month follow-up survey, with only about a quarter (232/1012, or 22.9%) of the original sample participants completing the follow-up survey. The low response rate may have been partially attributable to survey fatigue and inaccessibility (De Koning et al., 2021). To complete the mobile-based survey, participants used their mobile phones and cellular data. Participants might not have been able to access the

WhatsApp survey due to the cost of cellular data. In addition, participants' mobile phone numbers may have changed during the six-month interval, preventing them from receiving the 6-month follow-up survey. A possible solution to the low response rate after six months is to send out a personalised reminders to participants (Shiyab et al., 2023). By personalising the reminder and referring to the participant by name, it can generate 1.5 times more responses than non-personalised reminders (Shiyab et al., 2023). As an additional motivation to complete the follow-up survey, the incentive could be mentioned again in the reminder. Reminding participants of an incentive has shown an increase in response rates (Shiyab et al., 2023).

Another limitation of the study was the language the training material was available in. The training material was developed and administered in English through the 3E representatives. Numerous of the ECD practitioners who participated in the study's home language and second additional language was not English, which could have created an additional barrier in terms of the uptake of the training material. The 3E representatives were available if ECD practitioners required additional assistance i.e., translation of training information and clarification of content, yet the comprehensibility of the training material could have been limited for ECD practitioners whose home language or first additional language was not English.

4.4 FUTURE RESEARCH

Although training information was simple and easily comprehended by non-hearing professionals, future training material in versions that support different home languages should be explored. Culturally tailored training information may facilitate wider accessibility and improved comprehension especially for the classroom setting.

The qualitative component highlighted that ECD practitioners could identify children with hearing problems better, which carried over in the classroom setting. Future research can utilise this to develop training resources for ECD practitioners and teachers to further facilitate the process of aiding a child with a hearing loss before, during and post intervention.

The study identified that participants with *no formal training and other* had better pre-training scores than participants with *ECD level 1 to 5* educational training. This requires further investigation to substantiate these results by evaluating within-group demographics like practitioners' age, home language and the position at the ECD centre to substantiate this interesting occurrence.

The investigation indicated positive outcomes for increased knowledge scores of ECD practitioners and generalisability into real-world context such as the classroom setting, yet future investigation can evaluate the impact of an mHealth training programme on the identification of children with hearing problems. Due to the increased awareness of hearing health in children, it can be hypothesised that hearing problems can be identified in more children. Future research can investigate the efficacy and efficacy of the training programme in terms of identifying children with hearing problems. This is important as the training programme must demonstrate effectiveness in identifying children with hearing problems. The increased awareness of hearing health in children is futile if children with hearing problems are still not identified. Yet with an increase in the identification of children with hearing loss, the existing resources and infrastructure for early identification and intervention services may be further strained due to the scarcity of audiological services and resources to meet the needs of children with hearing loss. Furthermore, there could be challenges with access to specialised services, inclusive education and parental support and education. Addressing these challenges

72

requires collaborative efforts among parents, healthcare professionals, educators, policymakers, and communities. It involves improving access to specialised services, increasing funding for hearing healthcare, promoting early identification, and fostering inclusive educational settings that support the unique needs of children with hearing loss. It is essential to invest in the necessary infrastructure, technology, and training to ensure the successful implementation of tele-audiology services. By implementing tele-audiology strategies, it is possible to address the lack of available audiology services for children with hearing loss. It requires a multi-faceted approach involving investment in workforce development, leveraging technology, fostering collaborations, raising awareness, and advocating for policy changes and increased funding (WHO, 2021). The workforce development focuses on task-sharing which involves the redistribution of clinical task between health specialist and community healthcare workers to make more efficient use of the available healthcare providers (WHO, 2021). Moreover, these initiatives should be aligned with the national health priorities and integrated into existing policies and service-delivery frameworks.

4.5 CONCLUSION

ECD facilities may be the entry point of contact for hearing screening, particularly in countries with low SES. ECD practitioners' knowledge and perceptions regarding hearing health in young children are critical for primary and secondary prevention of childhood hearing loss. With generalisation maintained over time, a mHealth intervention programme can support improved knowledge and perceptions of ECD practitioners regarding hearing health for young children creating a scalable, affordable intervention for preventing childhood HL.

REFERENCES

Abraham, V. J., Balraj, V., Shankar, N., Job, A., & Joseph, A. (2003). Training teachers of day care centres for primary ear care. *Tropical doctor*, *33*(2), 98–100. https://doi.org/10.1177/004947550303300215

American Speech-Language-Hearing Association. (2020). *Early hearing detection & intervention action center (EHDI)*. Asha.org. Retrieved 15 December 2020, from https://www.asha.org/advocacy/federal/early-hearing-detection-and-intervention/.

American Speech-Language-Hearing Association. (2020). *Newborn hearing screening*. Asha.org. Retrieved 15 December 2020, from https://www.asha.org/practice-portal/professional-issues/newborn-hearing-screening/#collapse_3.

American Speech-Language-Hearing Association. (2021). How Does Your Child Hear and Talk? Speech, Language, and Hearing Developmental Milestones from Birth to 5 Years. (*American Speech Language and Hearing Association*) Asha.org. Retrieved 24 March 2021, from https://www.asha.org/public/speech/development/chart/.

Andrade C. (2018). Internal, External, and Ecological Validity in Research Design, Conduct, and Evaluation. *Indian journal of psychological medicine*, *40*(5), 498–499. https://doi.org/10.4103/IJPSYM.IJPSYM_334_18

Atashbahar, O., Sari, A. A., Takian, A., Olyaeemanesh, A., Mohamadi, E., & Barakati, S. H. (2022). The impact of social determinants of health on early childhood development: a qualitative context analysis in Iran. *BMC Public Health*, *22*(1), 1–13. https://doi.org/10.1186/s12889-022-13571-5

Austin, P. C., & Steyerberg, E. W. (2015). The number of subjects per variable required in linear regression analyses. *Journal of clinical epidemiology*, *68*(6), 627–636. https://doi.org/10.1016/j.jclinepi.2014.12.014

74

Bauer, M. S., & Kirchner, J. A. (2020). Implementation science: What is it and why should I care? *Psychiatry Research*, *283*(March 2019). https://doi.org/10.1016/j.psychres.2019.04.025

Bezuidenhout, J., Khoza-Shangase, K., De Maayer, T., & Strehlau, R. (2018). Universal newborn hearing screening in public healthcare in South Africa: Challenges to implementation. *South African Journal of Child Health*, *12*(4), 154. https://doi.org/10.7196/sajch.2018.v12i4.1522

Black, M., Walker, S., Fernald, L., Andersen, C., DiGirolamo, A., & Lu, C. et al. (2017). Early childhood development coming of age: science through the life course. *The Lancet*, *389*(10064), 77-90. https://doi.org/10.1016/s0140-6736(16)31389-7

Bowen, D. J., Kreuter, M., Spring, B., Cofta-Woerpel, L., Linnan, L., Weiner, D., Bakken, S., Kaplan, C. P., Squiers, L., Fabrizio, C., & Fernandez, M. (2010). How we design feasibility studies. *American journal of preventive medicine*, *36*(5), 452–457. https://doi.org/10.1016/j.amepre.2009.02.002

Brink, H., Van der Walt, C. and Van Rensburg, G., 2018. *Fundamentals of research methodology for healthcare professionals*. 4th ed. pp.81-100.

Brownson, R. C., Kumanyika, S. K., Kreuter, M. W., & Haire-Joshu, D. (2021). Implementation science should give higher priority to health equity. *Implementation Science*, *16*(1), 1–16. https://doi.org/10.1186/s13012-021-01097-0

Campbell-Barr, V. (2017). The silencing of the knowledge-base in early childhood education and care professionalism. *International Journal of Early Years Education*, *26*(1), 75–89. https://doi.org/10.1080/09669760.2017.1414689

Castro, T. T. de O., & Zucki, F. (2015). Training of Community Health Agents in health hearing children: Current perspectives. *Codas*, *27*(6), 616–622. https://doi.org/10.1590/2317-1782/20152014223

Chadha, S., Kamenov, K., & Cieza, A. (2021). The world report on hearing, 2021. *Bulletin of the World Health Organization*, *99*(4), 242–242A. https://doi.org/10.2471/BLT.21.285643

Chen, H., Ning, X., Wang, L., & Yang, J. (2018). Acquiring new factual information: Effect of prior knowledge. *Frontiers in Psychology*, *9*(SEP), 1–14. https://doi.org/10.3389/fpsyg.2018.01734

Ching, T. Y., Dillon, H., Marnane, V., Hou, S., Day, J., Seeto, M., Crowe, K., Street, L., Thomson, J., Van Buynder, P., Zhang, V., Wong, A., Burns, L., Flynn, C., Cupples, L., Cowan, R. S., Leigh, G., Sjahalam-King, J., & Yeh, A. (2013). Outcomes of early- and late-identified children at 3 years of age: findings from a prospective population-based study. *Ear and hearing*, *34*(5), 535–552. https://doi.org/10.1097/AUD.0b013e3182857718

Clark, J. L., & Swanepoel, deW. (2014). Technology for hearing loss - as we know it, and as we dream it. *Disability and rehabilitation. Assistive technology*, *9*(5), 408–413. https://doi.org/10.3109/17483107.2014.905642

Cohen, J. *Statistical Power Analysis for the Behavioral Sciences*; Academic Press: Cambridge, MA, USA, 1969.

Cole, E., & Flexer, C. (2020). *Children with hearing loss: developing listening and talking, birth to six* (4th ed., pp. 5-13).

Corrigan, J. A., & Onwuegbuzie, A. J. (2020). Toward a meta-framework for conducting mixed methods representation analyses to optimize meta-inferences. *Qualitative Report*, *25*(3), 785–812. https://doi.org/10.46743/2160-3715/2020.3579

Cortez, N., Cohen, I., & Kesselheim, A. (2014). FDA Regulation of Mobile Health Technologies. *New England Journal of Medicine*, *371*(4), 372-379. https://doi.org/10.1056/nejmhle1403384

de Koning, R., Egiz, A., Kotecha, J., Ciuculete, A. C., Ooi, S. Z. Y., Bankole, N. D. A., Erhabor, J., Higginbotham, G., Khan, M., Dalle, D. U., Sichimba, D., Bandyopadhyay, S., & Kanmounye, U. S. (2021). Survey Fatigue During the COVID-19 Pandemic: An

76

Analysis of Neurosurgery Survey Response Rates. *Frontiers in surgery*, 8, 690680. https://doi.org/10.3389/fsurg.2021.690680

Dillon, H., Cowan, R., & Ching, T. Y. C. (2013). Longitudinal outcomes of children with hearing impairment (LOCHI). *International Journal of Audiology, 52*(Suppl. 2), S2–S3.

Dugas, M., Gao, G. G., & Agarwal, R. (2020). Unpacking mHealth interventions: A systematic review of behavior change techniques used in randomized controlled trials assessing mHealth effectiveness. *Digital health*, 6, 2055207620905411. https://doi.org/10.1177/2055207620905411

Early, J., Gonzalez, C., Gordon-Dseagu, V., & Robles-Calderon, L. (2019). Use of mobile health (mHealth) technologies and interventions among community health workers globally: A scoping review. *Health Promotion Practice*, *20*(6), 805-817. https://doi.org/10.1177/1524839919855391

Eksteen, S., Eikelboom, R., Launer, S., Kuper, H., & Swanepoel, D. (2021). Referral Criteria for Preschool Hearing Screening in Resource-Constrained Settings: A Comparison of Protocols. *Language, Speech, and Hearing Services in Schools*, 1-9. https://doi.org/10.1044/2021_lshss-21-00008

Eksteen, S., Launer, S., Kuper, H., Eikelboom, R., Bastawrous, A., & Swanepoel, D. (2019). Hearing and vision screening for preschool children using mobile technology, South Africa. *Bulletin of The World Health Organization*, *97*(10), 672-680. https://doi.org/10.2471/blt.18.227876

Field, A. Second Edition of the Discovering Statistics Using SPSS Second Edition. 2005. Available online: http://users.sussex.ac.uk/~andyf/dsusflyer.pdf (accessed on 23 August 2022).

Gordon, S., & Harvey, J. (2019, October 2). South Africans prefer their children to be taught in English. *Quartz*. Retrieved May 6, 2023, from https://qz.com/africa/1720174/south-africans-prefer-their-children-to-be-taught-in-english

Grantham-McGregor, S., Cheung, Y., Cueto, S., Glewwe, P., Richter, L., & Strupp, B. (2007). Developmental potential in the first 5 years for children in developing countries. *The Lancet*, *369*(9555), 60-70. https://doi.org/10.1016/s0140-6736(07)60032-4

Guetterman, T. C., Fetters, M. D., & Creswell, J. W. (2015). Integrating quantitative and qualitative results in health science mixed methods research through joint displays. *Annals of Family Medicine*, *13*(6), 554–561. https://doi.org/10.1370/afm.1865

Henry, C., & Namhla, S. (2020). Continuous professional development for inclusive ECD teachers in Chiredzi Zimbabwe: Challenges and opportunities. *Scientific African*, *8*, e00270. https://doi.org/10.1016/j.sciaf.2020.e00270

Hirsh-Pasek, K., Adamson, L. B., Bakeman, R., Owen, M. T., Golinkoff, R. M., Pace, A., Yust, P. K., & Suma, K. (2015). The Contribution of Early Communication Quality to Low-Income Children's Language Success. *Psychological science*, *26*(7), 1071–1083. https://doi.org/10.1177/0956797615581493

Joint Committee on Infant Hearing (2007). Year 2007 position statement: Principles and guidelines for early hearing detection and intervention programs. *Pediatrics*, *120*(4), 898–921. https://doi.org/10.1542/peds.2007-2333

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. Retrieved 10 June 2021, from https://www.audiology.org/sites/default/files/publications/resources/2019_JointCommiteeInfantHearing_Principles_Guidelines4EarlyHearingDetectionInterventionProgrs.pdf.

Kazi, A. M., Ahsan, N., Jamal, S., Khan, A., Mughis, W., Allana, R., Kazi, A. N., Kalimuddin, H., Ali, S. A., McKellin, W., & Collet, J. P. (2021). Characteristics of mobile phone access and usage among caregivers in Pakistan - A mHealth survey of urban and rural population. *International journal of medical informatics*, *156*, 104600. https://doi.org/10.1016/j.ijmedinf.2021.104600

Khoza-Shangase, K., Kanji, A., & Ismail, F. (2021). What are the current practices employed by audiologists in early hearing detection and intervention in the South African healthcare context? *International Journal of Pediatric Otorhinolaryngology*, *141*, 110587. https://doi.org/10.1016/j.ijporl.2020.110587

Mahomed-Asmail, F., Swanepoel, D., Eikelboom, R., Myburgh, H., & Hall, J. (2016). Clinical validity of hearScreen™ smartphone hearing screening for school children. *Ear & Hearing*, *37*(1), e11-e17. https://doi.org/10.1097/aud.0000000000000223

Mantena, S., Celi, L., Keshavjee, S., & Beratarrechea, A. (2021). Improving community health-care screenings with smartphone-based AI technologies. *The Lancet Digital Health*, *3*(5), e280-e282. https://doi.org/10.1016/s2589-7500(21)00054-6

Marcolino, M. S., Oliveira, J. A. Q., D'Agostino, M., Ribeiro, A. L., Alkmim, M. B. M., & Novillo-Ortiz, D. (2018). The Impact of mHealth Interventions: Systematic Review of Systematic Reviews. *JMIR mHealth and uHealth*, *6*(1), e23. https://doi.org/10.2196/mhealth.8873

Neumann, K., Mathmann, P., Chadha, S., Euler, H. A., & White, K. R. (2022). Newborn hearing screening benefits children, but global disparities persist. *Journal of Clinical Medicine*, *11*(1). https://doi.org/10.3390/jcm11010271

Ojo, A. I. (2018). mHealth Interventions in South Africa: A Review. *SAGE Open*, *8*(1). https://doi.org/10.1177/2158244018767223

Olusanya, B. O., & Newton, V. E. (2007). Global burden of childhood hearing impairment and disease control priorities for developing countries. *Lancet (London, England)*, *369*(9569), 1314–1317. https://doi.org/10.1016/S0140-6736(07)60602-3

Olusanya, B. O., Davis, A., Wertlieb, D., Boo, N., Nair, M. K. C., Halpern, R., Kuper, H., Breinbauer, C., De Vries, P. J., Gladstone, M., Halfon, N., Kancherla, V., Mulaudzi, M. C., Kakooza-Mwesige, A., Ogbo, F. A., Olusanya, J. O., Williams, A., Wright, S. M., Manguerra, H., . . . Kassebaum, N. J. (2018). Developmental disabilities among children younger than 5 years in 195 countries and territories, 1990–2016: a systematic analysis for

the Global Burden of Disease Study 2016. *The Lancet Global Health, 6*(10), e1100–
e1121. https://doi.org/10.1016/s2214-109x(18)30309-

Olusanya, B., Luxon, L., & Wirz, S. (2004). Infant hearing screening: route to informed
choice. *Archives of Disease In Childhood*, *89*(11), 1039-1040.
https://doi.org/10.1136/adc.2004.051086

Pimperton, H., Blythe, H., Kreppner, J., Mahon, M., Peacock, J. L., Stevenson, J., Terlektsi,
E., Worsfold, S., Yuen, H. M., & Kennedy, C. R. (2016). The impact of universal newborn
hearing screening on long-term literacy outcomes: a prospective cohort study. *Archives of
disease in childhood*, *101*(1), 9–15. https://doi.org/10.1136/archdischild-2014-307516

Putcha, V., & van der Gaag, J. (2015). Investing in early childhood development: What is
being spent, and what does it cost? *Brookings*. Retrieved 14 April 2021, from
https://www.brookings.edu/research/investing-in-early-childhood-development-what-is-
being-spent-and-what-does-it-cost/.

Rassi, C., Gore-Langton, G. R., Gidudu Walimbwa, B., Strachan, C. E., King, R., Basharat,
S., Christiansen-Jucht, C., Graham, K., & Gudoi, S. S. (2018). Improving health worker
performance through text messaging: A mixed-methods evaluation of a pilot intervention
designed to increase coverage of intermittent preventive treatment of malaria in pregnancy
in West Nile, Uganda. *PloS one*, *13*(9), e0203554.
https://doi.org/10.1371/journal.pone.0203554

Regnault, A., Willgoss, T., & Barbic, S. (2018). Towards the use of mixed methods inquiry
as best practice in health outcomes research. *Journal of Patient-Reported Outcomes*, *2*, 2–
5. https://doi.org/10.1186/s41687-018-0043-8

Richardson, B., van der Linde, J., Pillay, B., & Swanepoel, D. (2021). Do text messages
about health and development in young children affect caregiver behaviour and child
outcomes? A systematic review. *Health Education Journal*, *80*(2), 225-237.
https://doi.org/10.1177/0017896920965992

Rhoades, E. A., & Duncan, J. (2017). *Auditory-verbal practice: Family-centered early intervention*. Charles C Thomas, Publisher, Ltd.

Robertson, C. M. T., Howarth, T. M., Bork, D. L. R., & Dinu, I. A. (2009). Permanent bilateral sensory and neural hearing loss of children after neonatal intensive care because of extreme prematurity: A third-year study. *Pediatrics, 123(5)*, e797- e807.

Roess, A. (2017). The promise, growth, and reality of mobile health — Another data-free zone. *New England Journal of Medicine*, *377*(21), 2010-2011. https://doi.org/10.1056/nejmp1713180

Rudd, B. N., Davis, M., & Beidas, R. S. (2020). Integrating implementation science in clinical research to maximize public health impact: a call for the reporting and alignment of implementation strategy use with implementation outcomes in clinical research. *Implementation Science*, *15*(1), 1–11. https://doi.org/10.1186/s13012-020-01060-5

Scholes, S., Biddulph, J., Davis, A., & Mindell, J. (2018). Socioeconomic differences in hearing among middle-aged and older adults: cross-sectional analyses using the Health Survey for England. *BMJ Open*, 8(2), e019615. https://doi.org/10.1136/bmjopen-2017-019615

Shambare R. The adoption of whatsApp: Breaking the vicious cycle of technological poverty in South Africa. *Journal of Economic and Behavioural Sudies* [Internet]. 2014; 6(7):542–50. Available from: https://www.researchgate.net/publication/338893943_The_Adoption_of_WhatsApp_Breaking_the_Vicious_Cycle_of_Technological_Poverty_in_South_Africa

Shiyab, W., Ferguson, C., Rolls, K., & Halcomb, E. (2023). Solutions to address low response rates in online surveys. *European journal of cardiovascular nursing*, zvad030. Advance online publication. https://doi.org/10.1093/eurjcn/zvad030

Smit, N., Van der Linde, J., Eccles, R., Swanepoel, D., & Graham, M. (2021). Exploring the knowledge and needs of early childhood development practitioners from a low-resource

community. Repository.up.ac.za. Retrieved 8 June 2021, from https://repository.up.ac.za/handle/2263/75974.

Smith, B., Zhang, J., Pham, G., Pakanati, K., Raol, N., Ongkasuwan, J., & Anne, S. (2019). Effects of socioeconomic status on children with hearing loss. *International Journal of Pediatric Otorhinolaryngology*, *116*, 114-117. https://doi.org/10.1016/j.ijporl.2018.10.032

Stark, A. L., Geukes, C., & Dockweiler, C. (2022). Digital Health Promotion and Prevention in Settings: Scoping Review. *Journal of medical Internet research*, *24*(1), e21063. https://doi.org/10.2196/21063

Statistics Africa. (2020). *More than 60% of South African children are poor*. Statssa.gov.za. Retrieved 14 June 2021, from http://www.statssa.gov.za/?p=13438.

Stensland, K. D., Sales, A. E., Damschroder, L. J., & Skolarus, T. A. (2022). Applying implementation frameworks to the clinical trial context. *Implementation Science Communications*, *3*(1), 1–13. https://doi.org/10.1186/s43058-022-00355-6

Stiles, D., McGregor, K., & Bentler, R. (2012). Wordlikeness and word learning in children with hearing loss. *International Journal of Language & Communication Disorders*, *48*(2), 200-206. https://doi.org/10.1111/j.1460-6984.2012.00199.x

Studts, C. R. (2022). Implementation science: Increasing the public health impact of audiology research. *American Journal of Audiology*, *31*(3S), 849–863. https://doi.org/10.1044/2022_AJA-21-00205

Swanepoel, D., & Clark, J. (2018). Hearing healthcare in remote or resource-constrained environments. *The Journal of Laryngology & Otology*, *133*(1), 11-17. https://doi.org/10.1017/s0022215118001159

Swanepoel, D., Myburgh, H., Howe, D., Mahomed, F., & Eikelboom, R. (2014). Smartphone hearing screening with integrated quality control and data management. *International Journal of Audiology*, *53*(12), 841-849. https://doi.org/10.3109/14992027.2014.920965

Swanepoel, D., Störbeck, C., & Friedland, P. (2009). Early hearing detection and intervention in South Africa. *International Journal of Pediatric Otorhinolaryngology*, *73*(6), 783-786. https://doi.org/10.1016/j.ijporl.2009.01.007

United Nations Population Fund East and Southern Africa Regional Office. (2019). *Republic of South Africa: Facts and prospects*. UNFPA ESARO. Retrieved 24 May 2021, from https://esaro.unfpa.org/en/publications/republic-south-africa-facts-and-prospects.

van der Merwe, M. F. (2020). Scaffolding for content knowledge of home language learning by collaborative online dictionaries. *Per Linguam*, *36*(1), 1–14. https://doi.org/10.5785/36-1-893

Van Niekerk, L., Ashley-Cooper, M., & Atmore, E. (2017). Effective early childhood development programme options meeting the needs of young South African children. *Centre for Early Childhood Development*. https://cecd.org.za/wp-content/uploads/2020/01/cecd-research-report-low-res.pdf

van Wyk, T. (2018). *Supporting hearing health for vulnerable populations affected and infected by HIV/AIDS using mobile technologies*. Repository.up.ac.za. Retrieved 28 January 2021, from https://repository.up.ac.za/bitstream/handle/2263/70527/VanWyk_Supporting_2018.pdf?sequence=1&isAllowed=y.

Wilson, B., Tucci, D., Merson, M., & O'Donoghue, G. (2017). Global hearing health care: new findings and perspectives. *The Lancet*, *390*(10111), 2503-2515. https://doi.org/10.1016/s0140-6736(17)31073-5

Windisch, O., Zamberg, I., Zanella, M. C., Gayet-Ageron, A., Blondon, K., Schiffer, E., & Agoritsas, T. (2020). Using mHealth to Increase the Reach of Local Guidance to Health Professionals as Part of an Institutional Response Plan to the COVID-19 Outbreak: Usage Analysis Study. *Journal of Medical Internet Research* (*JMIR) mHealth and uHealth*, *8*(8), e20025. https://doi.org/10.2196/20025

World Health Organization. (2006). Primary ear and hearing care training resource. Geneva (Switzerland). Accessed: 2 May 2020. Available from: www.who.int/pbd/ deafness/activities/hearing_care/advanced.pdf

World Health Organization. (2018). *Nurturing care for early childhood development. A global framework for action and results*. Who.int. Retrieved 15 December 2020, from https://www.who.int/maternal_child_adolescent/child/nurturing-care-framework-first-draft.pdf?ua=1.

World Health Organization. (2021). *Deafness and hearing loss*. Who.int. Retrieved 6 May 2021, from https://www.who.int/news-room/fact-sheets/detail/deafness-and-hearing-loss.

World Health Organization. (2021). *Hearing screening: Considerations for implementation*. World Health Organization. https://www.who.int/publications/i/item/9789240032767

World Health Organization. (2021). *World report on hearing*. Who.int. Retrieved 26 March 2021, from https://www.who.int/publications/i/item/world-report-on-hearing.

Yoshinaga-Itano, C., Sedey, A., Coulter, D., & Mehl, A. (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

Yousuf Hussein, S., Swanepoel, D., Biagio de Jager, L., & Mahomed-Asmail, F. (2018). Knowledge and attitudes of early childhood development practitioners towards hearing health in poor communities. *International Journal of Pediatric Otorhinolaryngology*, *106*, 16-20.

Yousuf Hussein, S., Swanepoel, D., Mahomed, F., & Biagio de Jager, L. (2018). Community-based hearing screening for young children using an mHealth service-delivery model. *Global Health Action*, *11*(1), 1467077.

Yousuf Hussein, S., Wet Swanepoel, D., Biagio de Jager, L., Myburgh, H. C., Eikelboom, R. H., & Hugo, J. (2016). Smartphone hearing screening in mHealth assisted community-

based primary care. *Journal of telemedicine and telecare*, 22(7), 405–412. https://doi.org/10.1177/1357633X15610721

Zamboni, J. (2019). The advantages of a large sample size. *Sciencing*. Retrieved January 29, 2023, from https://sciencing.com/advantages-large-sample-size-7210190.html

APPENDICES

Appendix A
Preliminary ethical clearance

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Humanities 100.
1919 - 2019

12 June 2019

Dear Prof Swanepoel

Project:	**Hearing and vision screening for preschool children using mHealth technologies: A community-based service-delivery model**
Researcher:	**Prof DCDE Swanepoel**
Department:	**Speech-Language Pathology and Audiology**
Reference number:	**GW20170922HS (Staff research) (Amendment to protocol)**

Thank you for the application to amend the existing protocol that was approved by the Committee on 4 October 2017.

I have pleasure in informing you that the amendment was **approved** the Research Ethics Committee at an *ad hoc* meeting held on 12 June 2019. Further data collection may therefore continue until June 2021 and is extended to include the Mbekwini area.

Please note that this approval is based on the assumption that the research will be carried out along the lines laid out in the initial proposal. Should your actual research depart significantly from the proposed research, it will be necessary to apply for a new research approval and ethical clearance.

We wish you success with the project.

Sincerely

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

Room ..., ... Building
University of Pretoria, Private Bag X20
Hatfield 0028, South Africa
Tel +27 (0)12 420 ...
Fax +27 (0)12 420 ...
Email ...@up.ac.za
www.up.ac.za

Faculty of Humanities
Fakulteit Geesteswetenskappe
Lefapha la Bomotho

Faculty of Humanities

Fakulteit Geesteswetenskappe
Lefapha la Bomotho

+umanITIES 100.
— Since 1919 —

![University of Pretoria crest]

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

29 June 2021

Dear Prof DCDW Swanepoel

Project Title:	GW20170922HS
Researcher:	Prof DCDW Swanepoel
Supervisor(s):	
Department:	Speech Language Path and Aud
Reference number:	02606623 (GW20170922HS) (Amendment)
Degree:	Staff Research / Non Degree

Thank you for the application to amend the existing protocol that was previously approved by the Committee.

The revised / additional documents were reviewed and **approved** on 29 June 2021 along these guidelines, further data collection may therefore commence (where necessary).

Please note that this approval is based on the assumption that the research will be carried out along the lines laid out in the amended proposal. Should your actual research depart significantly from the proposed research, it will be necessary to apply for a new research approval and ethical clearance.

We wish you success with the project.

Sincerely,

[signature]

Prof Karen Harris
Acting Chair: Research Ethics Committee
Faculty of Humanities
UNIVERSITY OF PRETORIA
e-mail: PGHumanities@up.ac.za

Fakulteit Geesteswetenskappe
Lefapha la Bomotho

Research Ethics Committee Members: **Prof I Pikirayi (Deputy Dean);** Prof KL Harris; Mr A Bizos; Dr A-M de Beer; Dr A dos Santos; Ms KT Govinder Andrew; Dr P Gutura; Dr E Johnson; Prof D Maree; Mr A Mohamed; Dr I Noomè; Dr C Puttergill; Prof D Reyburn; Prof M Soer; Prof E Taljard; Prof V Thebe; Ms B Tsebe; Ms D Mokalapa

89

Appendix B
Institutional ethical clearance

Faculty of Humanities

Fakulteit Geesteswetenskappe
Lefapha la Bomotho

4 August 2021

Dear Mr D du Plessis

Project Title:	mHealth-supported hearing health training for early childhood development practitioners: An intervention study
Researcher:	Mr D du Plessis
Supervisor(s):	Dr TE le Roux
	Prof DCDW Swanepoel
	Dr F Mahomed Asmail
Department:	Speech Language Path and Aud
Reference number:	17170941 (HUM044/0621)
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 29 July 2021 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 Innocent Pikirayi
Deputy Dean: Postgraduate Studies and Research Ethics
Faculty of Humanities
UNIVERSITY OF PRETORIA
e-mail: PGHumanities@up.ac.za

Fakulteit Geesteswetenskappe
Lefapha la Bomotho

Research Ethics Committee Members: Prof I Pikirayi (Deputy Dean); Prof KL Harris; Mr A Bizos; Dr A-M de Beer; Dr A dos Santos; Ms KT Govinder Andrew; Dr P Gutura; Dr E Johnson; Prof D Maree; Mr A Mohamed; Dr I Noomè; Dr C Puttergill; Prof D Reyburn; Prof M Soer; Prof E Taljard; Prof V Thebe; Ms B Tsebe; Ms D Mokalapa

91

© University of Pretoria

Appendix C
Written permission for use of data

Divan du Plessis
Department of Speech Language Pathology and Audiology
University of Pretoria

De Wet Swanepoel, Ph.D.
Department of Speech Language Pathology and Audiology
University of Pretoria

Dr. Faheema Mahomed-Asmail, Ph.D.
Department of Speech Language Pathology and Audiology
University of Pretoria

Talita le Roux, Ph.D.
Department of Speech Language Pathology and Audiology
University of Pretoria

11 June 2021

Dear Mr Divan du Plessis, Prof De Wet Swanepoel, Dr Faheema Mahomed-Asmail and Dr Talita le Roux,

Permission is hereby given to access data from the *Ears and Eyes for Education (3E) Project* towards the Masters level research study undertaken by Mr Du Plessis at the Department of Speech-Language Pathology and Audiology at the University of Pretoria.

As per your request letter, it is understood that the study - *mHealth-supported training hearing health for early childhood development practitioners: An intervention study*, will analyse the data collected retrospectively. The data will be provided with the permission of the hearX Foundation and the Carel du Toit Centre and Trust. This access will allow the researcher to analyse our anonymised data from the participants' answers to a pre-training survey, post-training survey and six-months post-training survey.

We understand that the study results will be used to draw up a dissertation article that will be submitted to an international journal to be published and that the article will be made available to the hearX Foundation once published.

93

This data is shared in accordance with ethical research principles and the researcher will not be allowed to share this with other researchers nor use this data for anything else than for research use. The data will also be stored in hardcopy in a secure space for a minimum of 15 years as per the research policies of the University of Pretoria.

We wish you all the best with your research and look forward to review the results. We believe that the study will have great value for future mHealth supported training and large scale impact especially in low- and middle income contexts.

Sincerely,

Tersia de Kock

Project Lead & Audiologist

Director: hearX Foundation

94

Appendix D
Initial phone call with community principals and teachers

SCRIPT A: First contact telephone call

1) Contact principal

b) <u>Introduction</u>
- Good day, my name is _____(3E representative's name) .
- I am calling from the Ears and Eyes for Education Programme (3E).
- Is it a convenient time for you to talk?
- We work at ECDs and primary schools in _____(school's area) where we do screening tests to check children's hearing and vision.
- Our team has conducted screening tests at your school.
  OR
- Our team has delivered our services at various schools in _____(name the area) and we hope to visit your school in the near future when schools reopen.

c) <u>Offering</u>
- While schools are closed 3E would like to offer a free basic training service to your school's teachers. This is a great time for your teachers to keep busy and learn things that will help children in your school and community.
- The topic: The importance of healthy ears and hearing for healthy learning.
- The goal: To train teachers on how to identify and assist children with possible ear disease and hearing problems at school.
- The training will be 4 sessions completed over 4 days over WhatsApp. Each session will be a short voice note and a picture that will be sent to the teacher's phone. It will take 5 minutes per day to complete.
- The training is free and the teachers will get a certificate of completion.
- Participants will be required to fill in some questions before and after the training and they will receive a certificate of completion.
- Will you be willing to tell your teachers about this free training and give their cellphone numbers so that we can call them?
- The teachers' cell phone number and name will remain confidential and will not be shared with anyone else.
- Will you please let the teachers know that_____(3E representative's name) will call them from this number I am calling from.
- Do you, as the principal, want your teachers to be part of this training?
- Do you also want to participate in the training? *(If the principal wants to participate in the training as well, then you can follow the 'YES' teacher script)*
- Do you have any questions?
- Closing message - if principal **agrees**:
  Thank you for your time today and for agreeing to be a part of this free training course for your teachers. If you could please send us a list of the names and cell phone numbers for all of the teachers in your school that would like to take part in this training program, after this phone call. You can send it to me on this number via WhatsApp. We will reach all of those teachers that want to do the training, but we will work on a first come first serve basis. Please contact us if you have any questions on 064 1322 848 which is the project administrator.
- Closing message - if principal **disagrees**:
  Thank you for your time today. We would love to give you another opportunity for this training if you change your mind. Please contact us if you have any

further questions on 064 1322 848. This free training course is beneficial for all principals, teachers and classroom assistants! We hope to hear from you soon.

2) Contact teacher

a) Introduction
● Good day, my name is _____(3E representative's name) .
● I am calling from the Ears and Eyes for Education Programme (3E).
● Your school's principal _____(principal's name) gave me your cell phone number and indicated that you may be interested in participating in our free training we are offering to all teachers in your school/ECD.
● Please note that your personal information will remain confidential and will not be shared with anyone.
● We work at ECDs and primary schools in _____(school's area) doing screening tests to check children's hearing and vision.
● Our team screened children's hearing at your school.
  OR
● Our team has screened at many schools in your area _____(name the area) and we hope to visit your school in the near future when schools reopen.

b) Offering
● This is a great time for teachers to learn things that will help children in your school and community.
● The topic of our training is: The importance of healthy ears and hearing for healthy learning.
● The goal of our training is: To train teachers on how to identify and assist children with possible ear disease and hearing problems at school.
● The training will be completed over 4 days over WhatsApp, which will include a voice note and an image outlining the training for that day.
● The training will only take 5 minutes per day to finish.
● The training is free and everyone who completes the training and answers some questions before and after the training, will receive a certificate at the end.
● Do you have any questions?
● Would you like to participate?

NO

● May I ask why you do not want to participate?
● Possible barriers:
  ○ no access to WhatsApp
  ○ no data
  ○ not interested
Thank you for your time today. We would love to give you another opportunity to do this training if you change your mind. Please contact us if you have any further questions on this number or on 064 1322 848.

YES

c) *Important participant information*
- Thank you for wanting to take part in this training.
- To make the training easier for you please can you give us this information:
    - Your language preference: isiXhosa/ English
    - Do you have WhatsApp?
    - Do you have some data and the internet on your phone/laptop? It will use very little data.
    - Would you be able to start with the first day of training tomorrow? It will not take more than 5 minutes of your time. If not, when will a suitable day be?
    - Please confirm the spelling of your name and surname for completion of your certificate. *(You can ask them to WhatsApp it to you)*
    - Do you agree to take part in our research by answering some questions before and after the training? The information will be kept for research and archiving purposes for 15 years. It will help to improve the training programme for other people that want to take part in the training.

d) *Explain next steps:*
- Directly after this phone call you will receive a WhatsApp message with what is going to happen over the next 4 days of training.
- The first WhatsApp message will have a link which you must click on to answer some quick questions.
    - The questionnaire is completed anonymously (you do not need to give your name).
    - Please send a WhatsApp message if you have any difficulty completing the form.
- For the next 4 days you will receive a voice note and picture over WhatsApp with training information. You can listen to the voice note many times and use the picture to help you learn.
- OPTIONAL (*same as above*): After the 4 days, I will call you at_____(time specified by teacher) to answer any questions you have.
- After the training, we will send you another link to click on for you to answer some final questions to see how much you have learnt.
- Your certificate of completion will be sent to you over WhatsApp.
- Please save this number of the 3E team on your phone.
- You can send any questions you may have to this number. If you do not have airtime/ data, feel free to send a 'please call me' and we will call you back.
- Do you have any questions?
- Have a lovely day and I will send you the outline of the training immediately after this phone call.

Appendix E
Informed consent letter

Consent form

Dear Teacher,

As researchers from the Department of Speech-Language Pathology and Audiology, University of Pretoria, we would like to invite you to volunteer to participate in a research project to determine your perceptions and awareness of untreated hearing health in young children.

You will receive training, through the EARS training program, that that will guide you regarding the importance of healthy hearing and healthy learning. The goal of the EARS training is to equip you with the necessary knowledge and practical tips that will assist you in playing an active role in the identification and support of children with potential hearing problems.

You will be expected to complete a short online questionnaire, that will be provided to you via WhatsApp, before the EARS training, and then another online questionnaire after the EARS training. Both questionnaires will take 5 minutes each to complete. Findings obtained from the questionnaires will help us to support and assist care workers and teachers in the future to promote knowledge and information on hearing health.

The data obtained from the questionnaires will be used for research purposes only. All identifying information will be kept confidential and data-analysis will be conducted anonymously, meaning that no one will know your answer. Participation in this research project is completely voluntary, therefore should you wish to withdraw from the research study at any stage you may do so without any negative consequences.

All data will be stored at the Department of Speech-Language Pathology and Audiology at the University of Pretoria for 15 years for research and archiving purposes. Should you require any further information regarding the research project, please do not hesitate to contact the student researcher and supervisors.

If you wish to take part in this project, you can tick the box on the online questionnaire page, by which you give your permission (consent), that your answers can be used in this study.

Thank you for showing interest in this research project.

Yours sincerely,

Tersia de Kock
Project manager
084 514 2086

Prof. De Wet Swanepoel
Research Supervisor

Dr Faheema Mahomed-Asmail
Research Supervisor

Dr Talita le Roux
Research Supervisor

Appendix F
WhatsApp pre-training
survey

Message before receiving the survey

Dear Teacher,

Welcome to the EARS training Program - we hope you enjoy the next few days with us!

The questions about hearing problems in children must be answered before your training starts the next day.

It will take less than 5 minutes to complete the 20 short questions.

We will use your participation number for the lucky draw after you have answered the second questionnaire at the end of the training.

Thank you for taking time to complete this form, we value your time and answers for this project.

Pre-training Survey with instructions

Instructions before the questionnaire

Please read the following instructions and answer the questions accordingly:

FIRST
Copy and paste this entire message to your chat box.
This can be done by following these instructions:
1. Long pressing on this entire message.
2. Select **copy**
3. Go to your chat box > press on the chat box > select **paste**.
4. Answer the questions

_____PART 1_____

Please answer the following questions by typing in your answer under the question.

1. What is your year of birth? (i.e. 1987)

2. What is your participation number that was sent to you? (i.e. P20)

- -

*Please answer the following questions by adding a * after your answer, to make it bold.*
- -

for example:
1. What is your favourite colour?
- *Blue
- *Green*
- *Orange
- *Yellow

The * can be found:
1. Go to the **123** button on keyboard.
2. Click on **#+-** button.
3. Select the *

- -

3. Permission
By selecting 'yes' below, you agree to take part in this research. Your answers will not be linked to your name. The answers will be used for research purposes and to improve the training program. We will keep your answers for 15 years.
*yes
*No

The full consent letter will be sent to you on request.
- -

4. What is your gender?
• *Male
• *Female
• *other
• *Prefer not to say

5. What is your home language?
• *Xhosa
• *English
• *Afrikaans
• *Zulu
• *other :
Please type in your home language next to "other" if you select it

6. Have you ever worked with a child who has a hearing problem?
• *Yes
• *No
• *Unsure

7. What is your role or position at the ECD centre/school?
• *Principal
• *Teacher
• *Assistant
• *Volunteer
• *Other :
Please type your role next to "other" if you select it

8. What level of training have you completed?
• *B. Ed degree
• *ECD level 6
• *ECD level 5
• *ECD level 4
• *ECD level 1 to 3
• *No formal training
• *other :
Please type your training next to "other" if you selected it

Pre – Questionnaire

Please answer the following questions by adding a * after your answer, to make it bold.

9. ECD staff and teachers know enough about hearing and hearing problems in children.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

10. A child can be born with a hearing problem.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

11. There are different types of hearing problems.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

12. Ear infections can cause hearing problems.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

13. It is important to know if a child has a hearing problem at an early age so that they can be helped.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

14. Hearing problems in young children cannot be treated.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

15. There are signs in a child's behaviour that may tell you if the child has a hearing problem.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree

- *Agree
- *Strongly agree

16. Hearing problems can make learning to read and write difficult.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

17. Hearing problems can make concentration in a classroom difficult.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

18. Even with treatment, children with hearing loss cannot achieve the same as other children in school.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

19. If someone thinks a child has a hearing problem the child should be sent to an Audiologist.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

20. A child with a hearing problem can hear better in school if they sit in the front row of the classroom.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
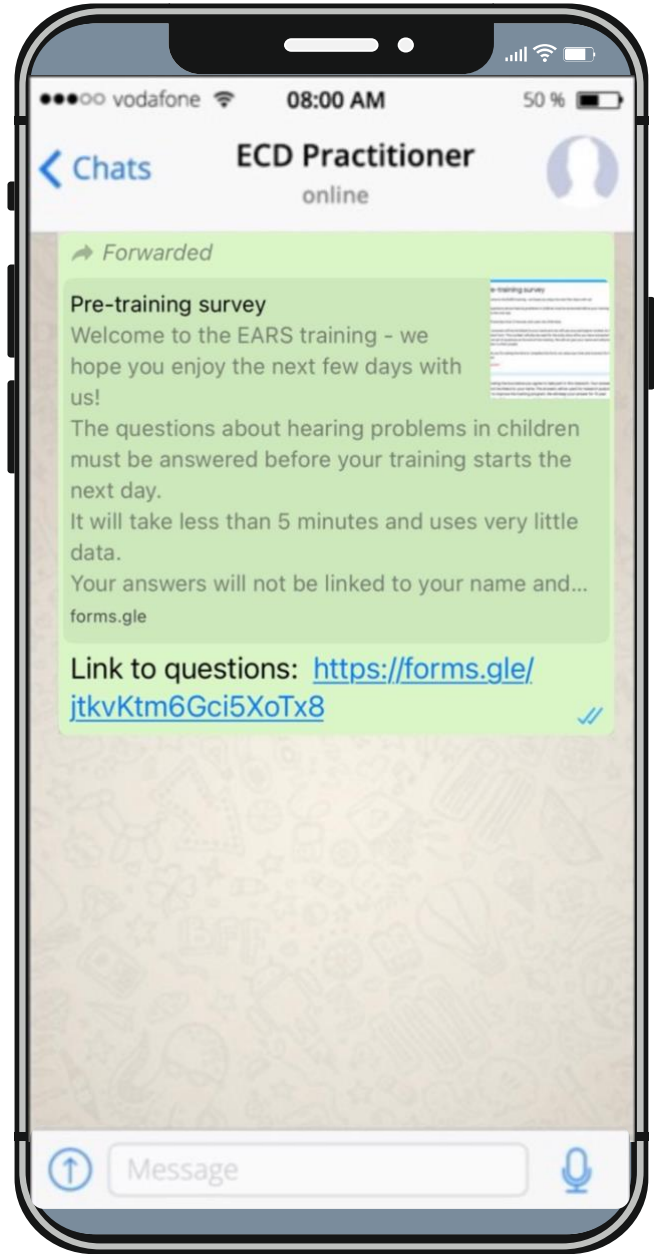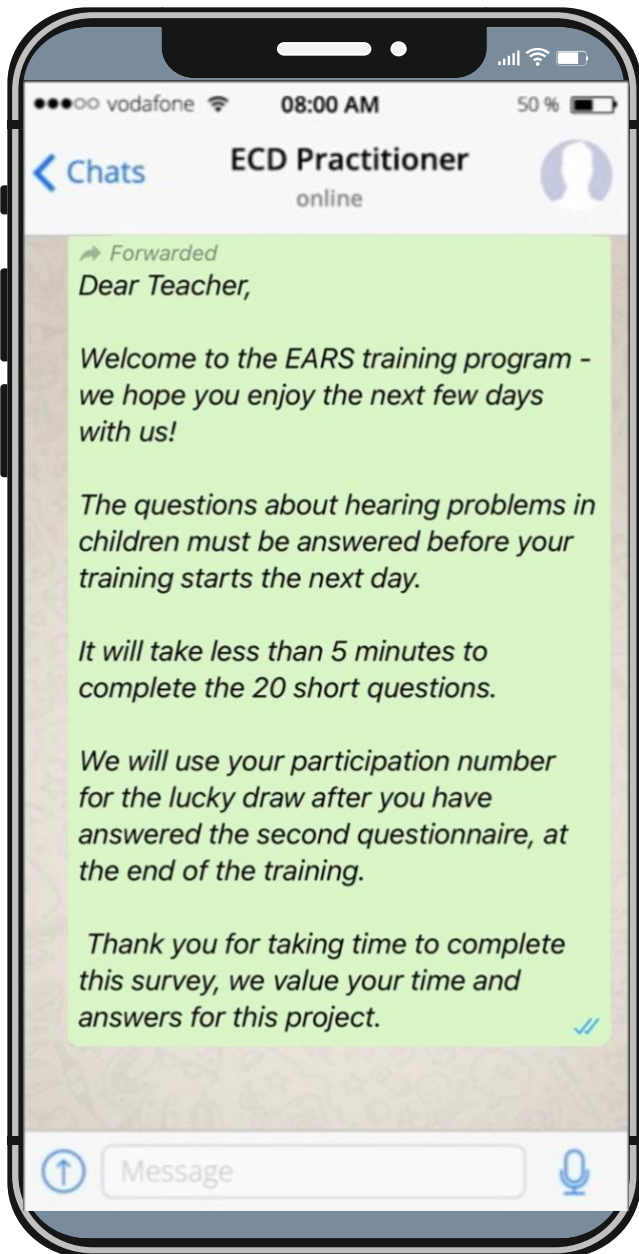- *Strongly agree

_____END_____

This is the end of questionnaire 1.

Further information will be sent to you once you have completed the training program.

Thank you for your participation once again.

106

Appendix G

Initial message with overview of training program and link to pre-training survey

Left phone:

●●●○○ vodafone 📶   08:00 AM   50 % 🔋

‹ Chats   **ECD Practitioner**
online

↱ *Forwarded*

Dear Teacher,

Welcome to the EARS training program - we hope you enjoy the next few days with us!

The questions about hearing problems in children must be answered before your training starts the next day.

It will take less than 5 minutes to complete the 20 short questions.

We will use your participation number for the lucky draw after you have answered the second questionnaire, at the end of the training.

Thank you for taking time to complete this survey, we value your time and answers for this project.

Message   🎤

Right phone:

●●●○○ vodafone 📶   08:00 AM   50 % 🔋

‹ Chats   **ECD Practitioner**
online

↱ *Forwarded*

Pre-training survey
Welcome to the EARS training - we hope you enjoy the next few days with us!
The questions about hearing problems in children must be answered before your training starts the next day.
It will take less than 5 minutes and uses very little data.
Your answers will not be linked to your name and...
forms.gle

Link to questions: https://forms.gle/jtkvKtm6Gci5XoTx8

Message   🎤

108

Appendix H
Message and six-months post-training follow-up survey

Message before receiving the survey

Dear participant,

Can you believe it's been six months since you've completed the EARS Teachers Training?!

As a final step of the research, we are inviting all participants to answer the training questions again.

It will take less than 5 minutes to complete the 16 short questions. Make sure you enter the correct participant number (sent to you on WhatsApp) - we will use this number for a lucky draw of 5 Shoprite/Checkers vouchers worth R350 each! We will not give your name and contact number to other people.

Thank you for taking the time to complete this form, we value your time and answers for this project!

draw of 5 Shoprite/Checkers vouchers worth R350 each! We will not give your name and contact number to other people.

Thank you for taking the time to complete this form, we value your time and answers for this project!

Post-training Survey with instructions

Six-month post-training survey

Dear participant,

Can you believe it's been six months since you've completed the EARS Teachers Training?!

As a final step of the research, we are inviting all participants to answer the training questions again.

It will take less than 5 minutes to complete the 16 short questions. Make sure you enter the correct participant number (sent to you on WhatsApp) - we will use this number for a lucky draw of 5 Shoprite/Checkers vouchers worth R350 each! We will not give your name and contact number to other people.

Thank you for taking the time to complete this form, we value your time and answers for this project!

* Required

What is your participation number? (i.e. P20) *

_____

What is your year of birth? (i.e. 1987) *

_____

Please indicate your answer by selecting the relevant option below:

1. ECD staff and teachers know enough about hearing and hearing problems in children. *
   Mark only one.

   ☐ Strongly agree
   ☐ Agree
   ☐ Neither agree or disagree
   ☐ Disagree
   ☐ Strongly Disagree

2. A child can be born with a hearing problem. *
   Mark only one.

   ☐ Strongly agree
   ☐ Agree
   ☐ Neither agree or disagree
   ☐ Disagree
   ☐ Strongly Disagree

3. There are different types of hearing problems. *
   Mark only one.

   ☐ Strongly agree
   ☐ Agree
   ☐ Neither agree or disagree
   ☐ Disagree
   ☐ Strongly Disagree

4. Ear infections can cause hearing problems. *
   Mark only one.

☐Strongly agree
☐Agree
☐Neither agree or disagree
☐Disagree
☐Strongly Disagree

5. It is important to know if a child has a hearing problem at an early age so that they can be helped. *
   Mark only one.

☐Strongly agree
☐Agree
☐Neither agree or disagree
☐Disagree
☐Strongly Disagree

6. Hearing problems in young children cannot be treated. *
   Mark only one.

☐Strongly agree
☐Agree
☐Neither agree or disagree
☐Disagree
☐Strongly Disagree

7. There are signs in a child's behaviour that may tell you if the child has a hearing problem. *
   Mark only one.

☐Strongly agree
☐Agree
☐Neither agree or disagree
☐Disagree
☐Strongly Disagree

8. Hearing problems can make learning to read and write difficult. *
   Mark only one oval.

☐Strongly agree
☐Agree
☐Neither agree or disagree
☐Disagree
☐Strongly Disagree

112

9. Hearing problems can make concentration in a classroom difficult. *
   Mark only one.

   ☐ Strongly agree
   ☐ Agree
   ☐ Neither agree or disagree
   ☐ Disagree
   ☐ Strongly Disagree

10. Even with treatment children with hearing loss cannot achieve the same as other children in school. *
    Mark only one.

    ☐ Strongly agree
    ☐ Agree
    ☐ Neither agree or disagree
    ☐ Disagree
    ☐ Strongly Disagree

11. If someone thinks a child has a hearing problem the child should be sent to an audiologist. *
    Mark only one.

    ☐ Strongly agree
    ☐ Agree
    ☐ Neither agree or disagree
    ☐ Disagree
    ☐ Strongly Disagree

12. A child with a hearing problem can hear better in school if they sit in the front row of the classroom. *
    Mark only one.

    ☐ Strongly agree
    ☐ Agree
    ☐ Neither agree or disagree
    ☐ Disagree
    ☐ Strongly Disagree

13. The information provided during the training program was meaningful to me. *
    Mark only one.

113

☐Strongly agree
☐Agree
☐Neither agree or disagree
☐Disagree
☐Strongly Disagree

14. The training improved my knowledge on hearing problems in young children. *
    Mark only one.

☐Strongly agree
☐Agree
☐Neither agree or disagree
☐Disagree
☐Strongly Disagree

15. After completing the EARS training, I am more aware of hearing problems in
    children than before.*
    Mark only one.

☐Strongly agree
☐Agree
☐Neither agree or disagree
☐Disagree
☐Strongly Disagree

16. Can you tell us of any way that you have used the information you received during
    the EARS Training?*
    Mark only one.

_____

_____

_____

_____

_____

End

This is the end of the questionnaire.

You will be contacted if your participation number was one of the 1 in 5 lucky numbers to be drawn for the voucher.

Thank you for your participation once again, we appreciate your time and effort.

Appendix I
English training material

'EARS' TRAINING PROGRAMME FOR TEACHERS

Training material

A. Introduction to 'EARS' training programme

*This is sent to the participant directly after the first contact telephone call as a written introduction to the training programme.

Duration: 1 min, 34 seconds

Welcome to the EARS training - we hope you enjoy the next few days with us!

You will start by answering a few questions. Please answer the questions today for your training to start tomorrow. It will take less than 5 minutes and use less than 20 kilobyte of data.

When the training starts, you will receive a picture and a voice note on WhatsApp every day for 4 days. Please work through the information carefully, it will take 5 minutes per day. At the end of the 4 days, we will send you another link with questions to find out if the training was valuable. If you complete the training and questions you will receive a certificate of completion.

Let's get started. As part of this message we sent you a link to the questions and your participant number. Please click on the link and complete the questions. Your answers will not be linked to your name. You will need to use your participant number on the question form. We will not give your name and cell phone number to other people. Use the questions to think about how much you know about hearing problems in children. Enjoy!

Training day 1: 'E' for Early

*Training day 1 starts on the day after the participant completed the pre-training questionnaire

Introduction - Duration: 1 min 09 seconds

Welcome to the EARS training programme for teachers, Early Childhood Development (ECD) practitioners, assistants and staff members working at ECD centres or in schools. We hope you enjoy this free training programme. The training will teach you about hearing problems in children and why children need to hear well to be able to learn. The training will equip you with knowledge and practical tips so that you can help pick up and support children with hearing problems. We use the letters E.A.R.S to set out the four areas that we will discuss during the training:

116

- **E** is for EARLY: Why is it important to pick up hearing problems early in children?
- **A** is for ACADEMICS: Why is healthy hearing important for healthy learning in children?
- **R** is for RED FLAGS: What are the warning signs of hearing problems in young children?
- **S** is for SUPPORT: How can teachers help and support children with hearing problems?

Day 1 - Duration: 2 min 51 seconds

Are you ready for the first day of the 'EARS' training?

Today we will learn why it is important to catch hearing problems in children **EARLY.**

A person with a hearing problem cannot hear some or any sounds. There are many different types of hearing problems and there are different reasons for these hearing problems. Hearing problems in children are common. One out of every 50 children will have a permanent hearing problem. This means that you will have children with hearing problems in your classroom sometime in your teaching career. Hearing problems in children can be caused by many different reasons, for example:

- when someone else in their family also has a hearing problem,
- when the baby's birth was difficult,
- diseases like meningitis, measles or mumps,
- some drugs like strong antibiotics in small babies,
- an injury to the head or ear,
- loud noises, or
- due to ear infections or too much wax in their ears.

Most hearing problems are invisible and young children cannot tell us when they cannot hear. This means it is not easy to know if a child has a hearing problem if you don't know what to look for. The ear may look normal to you, but the inside parts of the ear that send sound to the brain to hear, may not work well.

It is important to know if a child has a hearing problem at an early age so that they can be helped. Often hearing problems are only picked up in early school years. Adults start seeing that the child has behaviour problems and is not doing well with their school work.

Let's talk about ear health. Every time a child has an ear infection or too much wax in their ears, it can cause a hearing problem. Some children get ear infections often and if it is not treated for a long time the hearing problem can become permanent.

On day 3 and 4 of the training, we will look at warning signs that can tell you that a child might have a hearing problem and what you can do to help. If the hearing problem

117

is ignored and you don't do something about it, it can affect the child's language and speech development. This influences how they communicate with people, their school work and how they develop socially and emotionally. The good news - if the hearing problem is picked up early and the child has received the right treatment and support, they can achieve the same as a normal hearing child

Training day 2: 'A' for Academics

Duration: 2 min 59 seconds

Good-day and welcome to day 2 of the 'EARS' training.

Today we will learn why healthy hearing is important for healthy learning.

As you learnt yesterday, hearing problems that are not picked-up early can affect a child's overall development.

Please look at the picture that we have sent to you. It is the image of a triangle. It is split into three parts. The bottom and largest part of the triangle is HEARING. LANGUAGE AND SPEECH forms the middle part of the triangle and finally, LITERACY (the ability to read and write) forms the top and smallest part of the triangle.

We use this picture because HEARING is the first step towards language and speech development and LANGUAGE AND SPEECH is the next step towards LITERACY (reading and writing) and the best possible school performance.

Children need to be able to HEAR the words for them to LEARN the words. Without normal hearing, the child will not develop language and speech like other children their age who can hear. Imagine a noisy classroom full of children (that already gives us a headache doesn't it!). A child with a hearing problem sitting in such a noisy classroom really struggles. Children with hearing problems do not hear and learn in the same way that the other children in the class do. Because of their hearing problem, they have to use more brain power and energy to listen to their teacher and to focus in class. This is often the reason why hearing problems get missed in children, because many people think that the child is either naughty or has concentration problems.

So, what happens if there is a problem with hearing? Look at that picture of the triangle again. Hearing, as well as language and speech are the most important steps towards learning to read and write (literacy) and a child's school performance. Problems in these areas can cause learning difficulties (especially with reading, writing and mathematics) which can lead to poor progress in school. Children with untreated hearing problems can fail their grade more often.

Learning to read and write (literacy) is very important for later academic success which allows for work opportunities as adults.

Can you see why HEARING is so important in the overall development of children and their ability to learn and be included into society?

118

Wait for the next training sessions to learn how to know if a child has a hearing problem and what you can do to help....

Training day 3: 'R' for Red Flags

Duration: 3 minutes, 17 seconds

Good-day and welcome to day 3 of the 'EARS' training.

Today we will learn about the **red flags (warning signs) that can help us to pick up possible hearing problems in children.**

As you learnt in day 1 of our training, hearing problems are <u>invisible</u> and are not easy to pick up if you don't know what to look out for. Young children often cannot tell us that they cannot hear whilst teachers and parents will just think the child is naughty.

Let's learn a few important things before looking at the 'red flags' for hearing problems.

1. A child can be born with a hearing problem or develop a hearing problem later in life.
2. Some hearing problems are permanent (like when the inner ear or nerves are damaged) whilst others are temporary (like when a child has an ear infection or too much ear wax in their ears) and can be treated by a doctor or nurse.

'Red flags' in this training program means the 'warning signs' of hearing problems in children. Many hearing problems in children and the effect of these problems can be prevented.

The most important 'red flag' that we need to listen to is when parents, caregivers or teachers are worried. We must listen to that little voice inside of our heads - even if we can't explain it or know exactly why we are worried. If a teacher, parent or caregiver are worried about a child's hearing, the child must be sent to an audiologist for a hearing test. An audiologist is the health professional that tests children's hearing.

Please also be on the lookout for the following 'red flags' (warning signs) that can help you to pick up possible hearing problems in children:

- Behavioural problems (the child acts naughty and doesn't pay attention or seems distracted / very busy at times)
- Learning problems (children labelled as 'slow' learners)
- Poor or slow language and speech development (their language or ability to talk is not the same as other children their age)
- Not always responding when called by their name
- Often says ''huh?'' or ''what?''
- Need instructions to be repeated often
- Daydreaming in class

119

- Fluid/liquid coming out of the ears (regular ear infections)
- Sore or itchy ears

If you see any of these 'red flags' in a child, talk to the parent or caregiver. Ask them if they are also worried about their child's hearing.

All of the above 'red flags' must alert us of a possible hearing problem. Tomorrow we will talk about what you need to do to SUPPORT children when you see any warning signs.

Training day 4: 'S' for Support

Duration: 4 minutes, 56 seconds

Good-day and welcome to day 4 of the 'EARS' training.

Today we will learn how teachers can help and SUPPORT children with hearing problems.

We will be discussing two parts of SUPPORT:

1. What you should do if you see any 'red flags' (warning signs) of a hearing problem in a child,
2. How a teacher can support the child with a hearing problem in the classroom.

Never think that the hearing problem will get better by itself, rather send them to an audiologist for a hearing test. Can you still remember what we discussed on day 1 of our training? Looking at the ear from the outside is not enough to know if a child can hear - a proper hearing test by an audiologist must be done to know what a child can HEAR.

Please follow these steps if you are worried about a child's hearing:

1) Support the child's parents or caregivers and encourage them to get their child's hearing tested.
2) The parent or caregiver and the child must first visit the local clinic and see the nurse where they can ask for an appointment with the audiologist.
3) Please write a note, explaining your worries about the child, so that the parent or caregiver can give it to the nurse at the clinic. The note will motivate the need for a referral to see an audiologist.

You play a very important role in motivating the parent or caregiver to take the child to the local clinic for help. Thinking that your child may have a hearing problem can be scary and each parent or caregiver will react differently. Listen to their feelings and encourage them with the information that you have learnt here to help their child as soon as possible.

120

As mentioned on Day 1 of training, there are many different types of hearing problems and there are different causes for these hearing problems. This also means that hearing problems need to be treated differently. Children with ear infection need to see a doctor or nurse to get the correct medicine or ear drops. Children that have too much wax in their ears may need it removed and this can only be done by a nurse or doctor. In more serious cases, when the hearing problem is permanent, a child may need hearing aids to help them hear better. The audiologist will help with everything around hearing aids.

2. Now let's turn our focus to the classroom. How can you support a child with a hearing problem in your class?

Here are a few general strategies that you can use:

- Seat the child in the front row of the classroom
- Ensure that you get the child's attention before speaking to him/her
- Talk clearly and naturally, don't raise your voice (don't shout at him/her)
- Ensure that he/she can clearly see your face when speaking to them
- Make sure that you repeat important instructions
- Use visual cues (such as pictures) to help the child understand
- Encourage him or her to participate in group activities
- Keep unnecessary noise to a minimum (for example, close windows if it is noisy outside, make sure children in class are quiet when the teacher speaks)
- Do not give unnecessary attention to the child because of their hearing problem. Do not allow bullying.

If the child is fitted with hearing aids, the audiologist can provide you with tips on how to support them. You can ask the parents or caregivers for the contact information of the audiologist. For example, the hearing aids will have to be checked on a daily basis to be sure they are working properly.

Children with hearing problems often need extra support such as speech therapy. Speak to your school's principal or contact the local clinic to learn more about the options for support that are available.

Thank you for finishing the EARS training programme. We hope that you enjoyed the training and that you will keep your eyes and ears open to make sure that the children in your class have healthy hearing for healthy learning.

Appendix J
Online pre-training survey

Pre-training survey

Welcome to the EARS training program - we hope you enjoy the next few days with us!

The questions about hearing problems in children must be answered before your training starts the next day.

It will take less than 5 minutes and uses very little data.

Your answers will not be linked to your name and we will use your participant number (the number sent to you on WhatsApp) on the question form. This number will also be used for the lucky draw after you have answered the second set of questions at the end of the training. We will not give your name and cell phone number to other people.

Thank you for taking the time to complete this form, we value your time and answers for this project.

* Required

1. By ticking the box below you agree to take part in this research. Your answers will not be linked to your name. The answers will be used for research purposes and to improve the training program. We will keep your answer for 15 year. Read the full research consent letter here: http://tiny.cc/tax6qz *

Check all that apply.

☐ I agree to take part in this research

2. What is your participation number? The number sent to you on WhatsApp (i.e. P20) *

_____

3. What is your year of birth? (i.e. 1987) *

_____

4. What is your gender? *
Mark only one.

☐ Male
☐ Female
☐ Prefer not to say
☐ Other: _____

123

5. What is your home language? *
Mark only one.

☐ Xhosa
☐ English
☐ Afrikaans
☐ Zulu
☐ Other: _____

6. Have you ever worked with a child who has a hearing problem? *
Mark only one.

☐ Yes
☐ No
☐ Unsure

7. What is your role or position at the ECD centre / school? *
Mark only one.

☐ Principal
☐ Teacher
☐ Assistant
☐ Volunteer
☐ Other: _____

8. What level of training have you completed?
Mark only one.

☐ B. Ed degree
☐ ECD level 6
☐ ECD level 5
☐ ECD level 4
☐ ECD level 1 to 3
☐ No formal training
☐ Other: _____

124

Please indicate your answer by selecting the relevant option below:

9. ECD staff and teachers know enough about hearing and hearing problems in children. *
Mark only one.

☐ Strongly agree
☐ Agree
☐ Neither agree or disagree
☐ Disagree
☐ Strongly Disagree

10. A child can be born with a hearing problem. *
Mark only one.

☐ Strongly agree
☐ Agree
☐ Neither agree or disagree
☐ Disagree
☐ Strongly Disagree

11. There are different types of hearing problems. *
Mark only one.

☐ Strongly agree
☐ Agree
☐ Neither agree or disagree
☐ Disagree
☐ Strongly Disagree

12. Ear infections can cause hearing problems. *
Mark only one.

☐ Strongly agree
☐ Agree
☐ Neither agree or disagree
☐ Disagree
☐ Strongly Disagree

13. It is important to know if a child has a hearing problem at an early age so that they can be helped. *
Mark only one.

☐Strongly agree
☐Agree
☐Neither agree or disagree
☐Disagree
☐Strongly Disagree

14. Hearing problems in young children cannot be treated. *
   Mark only one.

☐Strongly agree
☐Agree
☐Neither agree or disagree
☐Disagree
☐Strongly Disagree

15. There are signs in a child's behaviour that may tell you if the child has a hearing
    problem. *
    Mark only one.

☐Strongly agree
☐Agree
☐Neither agree or disagree
☐Disagree
☐Strongly Disagree

16. Hearing problems can make learning to read and write difficult. *
    Mark only one oval.

☐Strongly agree
☐Agree
☐Neither agree or disagree
☐Disagree
☐Strongly Disagree

17. Hearing problems can make concentration in a classroom difficult. *
    Mark only one.

☐Strongly agree
☐Agree
☐Neither agree or disagree
☐Disagree
☐Strongly Disagree

126

18. Even with treatment children with hearing loss cannot achieve the same as other children in school. *
    Mark only one.

    ☐ Strongly agree
    ☐ Agree
    ☐ Neither agree or disagree
    ☐ Disagree
    ☐ Strongly Disagree

19. If someone thinks a child has a hearing problem the child should be sent to an audiologist. *
    Mark only one.

    ☐ Strongly agree
    ☐ Agree
    ☐ Neither agree or disagree
    ☐ Disagree
    ☐ Strongly Disagree

20. A child with a hearing problem can hear better in school if they sit in the front row of the classroom. *
    Mark only one.

    ☐ Strongly agree
    ☐ Agree
    ☐ Neither agree or disagree
    ☐ Disagree
    ☐ Strongly Disagree

End

This is the end of questionnaire 1.

Further instructions will be sent to you once you have completed the training program.

Thank you for your participation once again.

127

Appendix K
Online post-training survey

Post-training survey

1. What is your participation number? The number sent to you on WhatsApp (i.e. P20) *

_____

2. What is your year of birth? (i.e. 1987) *

_____

Please indicate your answer by selecting the relevant option below:

3. ECD staff and teachers know enough about hearing and hearing problems in children. *
Mark only one.

☐ Strongly agree
☐ Agree
☐ Neither agree or disagree
☐ Disagree
☐ Strongly Disagree

129

4. A child can be born with a hearing problem. *
Mark only one.

☐Strongly agree
☐Agree
☐Neither agree or disagree
☐Disagree
☐Strongly Disagree

5. There are different types of hearing problems. *
Mark only one.

☐Strongly agree
☐Agree
☐Neither agree or disagree
☐Disagree
☐Strongly Disagree

6. Ear infections can cause hearing problems. *
Mark only one.

☐Strongly agree
☐Agree
☐Neither agree or disagree
☐Disagree
☐Strongly Disagree

7. It is important to know if a child has a hearing problem at an early age to help them. *
Mark only one.

☐Strongly agree
☐Agree
☐Neither agree or disagree
☐Disagree
☐Strongly Disagree

8. Hearing problems in young children cannot be treated. *
Mark only one.

☐Strongly agree
☐Agree
☐Neither agree or disagree

130

© University of Pretoria

☐Disagree
☐Strongly Disagree

9. There are signs in a child's behaviour that may tell you if the child has a hearing problem. *
   Mark only one.

   ☐Strongly agree
   ☐Agree
   ☐Neither agree or disagree
   ☐Disagree
   ☐Strongly Disagree

10. Hearing problems can make learning to read and write difficult. *
    Mark only one oval.

    ☐Strongly agree
    ☐Agree
    ☐Neither agree or disagree
    ☐Disagree
    ☐Strongly Disagree

11. Hearing problems can make concentration in a classroom difficult. *
    Mark only one.

    ☐Strongly agree
    ☐Agree
    ☐Neither agree or disagree
    ☐Disagree
    ☐Strongly Disagree

12. Even with treatment children with hearing loss cannot achieve the same as other children in school. *
    Mark only one.

    ☐Strongly agree
    ☐Agree
    ☐Neither agree or disagree
    ☐Disagree
    ☐Strongly Disagree

131

13. If someone thinks a child has a hearing problem the child should be sent to an audiologist. *
   Mark only one.

   ☐ Strongly agree
   ☐ Agree
   ☐ Neither agree or disagree
   ☐ Disagree
   ☐ Strongly Disagree

14. A child with a hearing problem can hear better in school if they sit in the front row of the classroom. *
   Mark only one.

   ☐ Strongly agree
   ☐ Agree
   ☐ Neither agree or disagree
   ☐ Disagree
   ☐ Strongly Disagree

15. The information provided during the training program was meaningful to me. *
   Mark only one.

   ☐ Strongly agree
   ☐ Agree
   ☐ Neither agree or disagree
   ☐ Disagree
   ☐ Strongly Disagree

16. The training improved my knowledge on hearing problems in young children. *
   Mark only one.

   ☐ Strongly agree
   ☐ Agree
   ☐ Neither agree or disagree
   ☐ Disagree
   ☐ Strongly Disagree

End
This is the end of questionnaire 2.

You will receive further information regarding your certificate of training completion and, if your participation number was one of the 1 in 10 lucky numbers to be drawn for the voucher.

Thank you for your participation once again, we appreciate your time and effort.

Appendix L
WhatsApp post-training survey

Message before receiving the survey

Dear Teacher,

Well done on completing the EARS training program - we hope you enjoyed the training with us!

You will now answer the second set of questions about hearing problems in children.

It will take less than 5 minutes to complete the 16 short questions.

We will use your participation number for the lucky draw after you have answered this questionnaire. We will not give your name or cell phone number to other people.

Thank you for taking time to complete this survey, we value your time and answers for this project.

Post-training Survey with instructions

Instructions before the questionnaire

Please read the following instructions on how you should answer the questions:

FIRST
Copy and paste this entire message to your chat box.
This can be done by following these instructions:
1. Long pressing on this entire message.
2. Select **copy**
3. Go to your chat box > press on the chat box > select **paste**.
4. Answer the questions

_____PART 1_____

Please answer the following questions by typing in your answer under the question.

1. What is your year of birth? (i.e. 1987)

2. What is your participation number that was sent to you? (i.e. P20)

- -

*Please answer the following questions by adding a * after your answer, to make it bold.*
- -

for example:
1. What is your favourite colour?
• *Blue
• *Green*
• *Orange
• *Yellow

The * can be found:
1. Go to the **123** button on keyboard.
2. Click on **#+-** button.
3. Select the *

_____**PART 2**_____

Post – Questionnaire

*Please answer the following questions by adding a * after your answer, to make it bold.*

3. ECD staff and teachers know enough about hearing and hearing problems in children.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

4. A child can be born with a hearing problem.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

5. There are different types of hearing problems.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

6. Ear infections can cause hearing problems.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

7. It is important to know if a child has a hearing problem at an early age so that they can be helped.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

8. Hearing problems in young children cannot be treated.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

9. There are signs in a child's behaviour that may tell you if the child has a hearing problem.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

10. Hearing problems can make learning to read and write difficult.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

11. Hearing problems can make concentration in a classroom difficult.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

12. Even with treatment, children with hearing loss cannot achieve the same as other children in school.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

13. If someone thinks a child has a hearing problem the child should be sent to an Audiologist.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

14. A child with a hearing problem can hear better in school if they sit in the front row of the classroom.
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

15. Was the information provided to you during the training program meaningful?
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

16. Would you say your knowledge on hearing health in young children improved after the training program?
- *Strongly disagree
- *Disagree
- *Neither agree or disagree
- *Agree
- *Strongly agree

_____**END**_____

This is the end of questionnaire 2.

You will receive further information regarding your certificate of training completion.

Thank you for your participation once again, we appreciate your time and effort.

Appendix M
Welcoming image with instructions

EARS Teacher Training Programme

WELCOME
& thanks for joining the EARS training

Step 1:
Listen to the voice note

Step 2:
Check your participant number

Step 3:
Click on the link and answer the questions

Please answer the questions today for your training to start tomorrow.

139

Appendix N
Daily images

EARS — Teacher Training Programme

DAY 1:
E = EARLY

Why is it important to pick up hearing problems early in children?

* The earlier we know about a child's hearing problem, the better the child can be helped.

* Hearing problems are often invisible - the ears might look normal but they might not work well.

* Teachers play an important role in picking up hearing problems because young children can not tell us that they can not hear.

EARS **Teacher Training Programme**
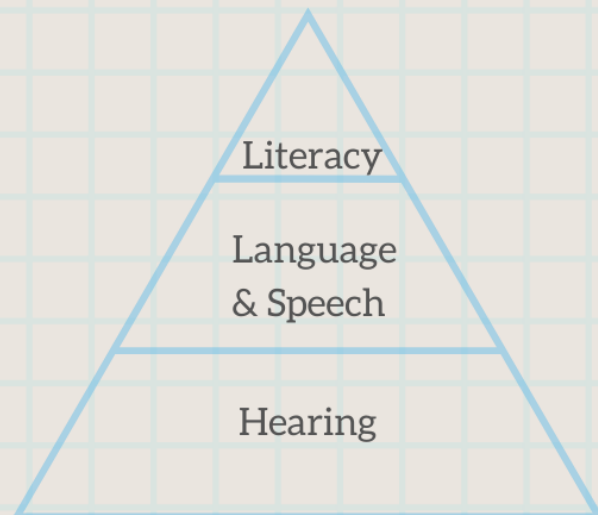
3e EARS & EYES FOR EDUCATION

DAY 2:
A = ACADEMICS

Why is healthy hearing important for healthy learning?

✳ If a child cannot hear, they cannot learn language or speech (how to talk).

✳ Language and speech are the steps towards learning to read and write (literacy).

Literacy

Language & Speech

Hearing

142

EARS Teacher Training Programme

DAY 3:
R = RED FLAGS

What are the signs of hearing problems in children?

Help to identify possible ear or hearing problems by looking out for these '**red flags**' (warning signs):

- Behavioural problems (naughty or doesn't pay attention)
- Learning problems ('slow' learners)
- Poor or slow language and speech development
- Not always responding when called by their name
- Often says "huh?" or "what?"
- Need instructions to be repeated often
- Daydreaming in class
- Fluid/liquid coming out of the ears (regular ear infections)
- Sore or itchy ears

EARS Teacher Training Programme

3e — EARS & EYES FOR EDUCATION

DAY 4: S = SUPPORT

How can teachers help and support children with hearing problems?

Support children with potential ear or hearing problems:

Refer them - it won't get better by itself, they need professional help

Help them in class -
→ place them in front;
→ get their attention before speaking to them;
→ ensure they can see your face when speaking to them;
→ encourage them to participate;
→ repeat important instructions.

144

Appendix O
Post-training message to participants

A. Final message post training

Duration: 1 min, 26 seconds

Congratulations! You have now completed the EARS training programme. As a final step, please complete the second set of questions. It will take less than 5 minutes and uses very little data. If you only have WhatsApp data, please ask your facilitator for the WhatsApp version. If you complete the questions you will receive a certificate of completion which we will send to you via WhatsApp.

Just a reminder - your answers will not be linked to your name. You will use your participant number on the question form. We sent this number to you at the beginning of the training. We will not give your name and cell phone number to other people.

Lastly, if you know any other teachers that you think will benefit from this training - please give us their details or ask them to contact us.

We hope that you enjoyed the training and that you will keep your eyes and ears open to make sure that the children in your class have healthy hearing for healthy learning.

146

Appendix P
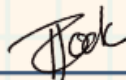## Certificate of completion
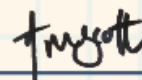
hearX foundation

CERTIFICATE OF COMPLETION

THIS CERTIFICATE GOES TO

Example

for completing the
EARS Teacher Training Programme on the
importance of healthy hearing for healthy learning
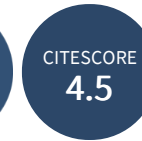[Month} [Year]

TERSIA DE KOCK
Director (hearX Foundation)

NICOL TRUSCOTT
Project Manager (3E Paarl Valley)

Appendix Q
Certificate of publication

International Journal of
**Environmental Research
and Public Health**

an Open Access Journal by MDPI

Indexed in:
PubMed

CITESCORE
4.5

IMPACT
FACTOR
4.614

CERTIFICATE OF PUBLICATION

Certificate of publication for the article titled:

mHealth-Supported Hearing Health Training for Early Childhood Development
Practitioners: An Intervention Study

Authored by:

Divan du Plessis; Faheema Mahomed-Asmail; Talita le Roux; Marien Alet Graham; Tersia
de Kock; Jeannie van der Linde;
De Wet Swanepoel

Published in:

Int. J. Environ. Res. Public Health **2022**, Volume 19, Issue 21, 14228

MDPI | Academic Open Access Publishing
since 1996

Basel, October 2022