AUDIOLOGY AND COMMUNITY-BASED REHABILITATION IN THE DEMOCRATIC REPUBLIC OF THE CONGO: DEVELOPMENT OF THE FIRST HEARING SCREENING TOOLS FOR INFANTS AND CHILDREN.

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aus

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DECLARATION

Declaration according to § 11 (1) 7

I hereby declare in lieu of oath that I have written my thesis independently and without undue assistance, that I have indicated all sources and aids used and that I have indicated the parts of my thesis, including tables, maps and illustrations taken from other works in wording or meaning as borrowings in each individual case; that this thesis has not yet been submitted to any other department for examination; that it has not yet been published; and that I will not publish it before completion of the doctoral procedure. I am aware of the Doctoral Regulations. The enclosed thesis was supervised by ***Jun. Prof. Dr. Karolin Schäfer*** and ***Prof. Dr. Ir. Frans Coninx***

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Foreword

The World Health Organization (WHO, 2018) estimates that there are 466 million people in the world with disabling hearing loss, equating to 6.1% of the world's population. Among this group, 34 million (7%) are children. In addition, the prevalence of disabling hearing loss in children is greatest in South Asia, Asia-Pacific, and sub-Saharan Africa (WHO, 2012).

Screening for hearing loss is the first stage of medical diagnosis. In past decades, several methods have been developed for hearing screening, such as newborn hearing screening (NBHS), which became the normal method of screening in the United States, and whereby almost all the states had legislation requiring the screening of newborns (NCHAM), 2011). To raise the issue and importance of screening for hearing loss among newborns worldwide, the WHO made a resolution urging member nations to make plans and implement screening programmes for early identification of ear diseases and hearing loss in infants and children (WHO, 1995).

Recent research by Neumann et al. (2019), demonstrated key conditions for the effectiveness of NBHS programmes. These prerequisites include: governmental mandates and guidance; presence of a national committee with involvement of professionals, industries, and stakeholders; central oversight of hearing screening; a clear definition of target parameters; presence of tracking systems with bi-directional data transfer from screening devices to screening centres; accessibility of paediatric audiological services and rehabilitation programmes; using telemedicine where connectivity is available; and the opportunity for case discussions in professional excellence circles with boards of experts.

In Europe, the implementation of the hearing screening programmes is mainly mandated or supported by the central health authorities based on physiological methods – otoacoustic emissions/auditory brainstem response (OAE/ABR) – which are considered the global Gold Standard to detect children with hearing loss as early as possible. European nations follow this approach despite a diversity in programmes, policy decisions, financing, general designs and organizational choices (Bénédicte et al., 2016; WHO, 2010; Neumann, 2006). However, despite the introduction and implementation of universal newborn hearing screening (UNHS) programmes and its progress in the developed world, progress has been much slower in developing countries (Swanepoel, Louw & Hugo, 2007). This slow implementation in some African countries and the total absence of any UNHS programme in other developing countries, such as the Democratic Republic of the Congo (DRC), coupled with limited hearing health professional, assessment equipment and amplification, is unaffordable for most of these communities (Brouillette, 2008). The main objective of this document of this study is aimed at developing the first hearing test tool, adapted to national languages, for the early detection of children at risk of hearing loss. Finally, it provides an overview of the future of hearing care programmes and the need for the prevention, identification and treatment of hearing loss in developing countries of the world.

This Gold Standard approach is currently not followed in much of Africa, and this includes the DRC.

Early detection and intervention have a significant effect on the quality of life of a child with hearing loss and his/her family. In the DRC, the options of hearing aids and rehabilitation exist but on a small scale, especially through the audiology and ENT departments. and also the option of cochlear implants is possible, depending on the possibilities and collaboration between the existing services. However, many children do not have the opportunity of getting

their auditory abilities tested and monitored early in life. The main challenges to early identification in the DRC include: the absence of national policies for NBHS, the lack of appropriate tools to test and monitor the hearing development of children when they are very young and the lack of supportive services. The lack of auditory testing in the DRC is the primary motivation for this thesis. This thesis is based around the attempt to develop the first hearing test tool, adapted to national languages, simple to use by a guardian, teacher, medical or paramedical personnel, for the purpose of early screening and to diagnose hearing loss in the DRC.

Abstract

Historically, there have been many tests that have been developed and used to screen and diagnose hearing loss, based on physiological methods. In many developed countries, the implementation of the hearing screening programmes was mainly mandated by the central health authorities, and newborn hearing screening (NHS) became the global golden standard for hearing screening, despite the key conditions for its effectiveness requiring adequate resources (Neumann et al., 2019). But this is not the case in the DRC where there is no national policy for a NHS programme, no test has been developed and adapted so far for hearing screening, and the prevalence, as well as the surveillance, of hearing loss is difficult to document and monitor. Therefore, this study is aimed at developing the first hearing test tool, adapted to national languages, for the early detection of children at risk of hearing loss, and how it can be integrated into the primary health care system in response to the permanent consequences of diseases and factors leading to deafness in the DRC.

Specific objectives included adapting and evaluating the effectiveness of the LittlEARS Auditory Questionnaire (LEAQ) as a screening tool for hearing loss in children aged 0–24 months in the DRC; constructing and validating the Kiswahili versions of the Adaptive Auditory Speech Test (AAST) for children aged 3–4 years and older; and determining the role of the LEAQ and the AAST as hearing screening tools in the community-based rehabilitation (CBR) programme.

Methods

A cross-sectional design was used to select a total of 1.501 participants for the study. The sample included children, adolescents and adults including parents. For validation of the LEAQ, norm data were collected from (N=723) babies for the Lingala version and (N=648) babies for the Kiswahili version for children (0–24 months). In order to investigate the effectiveness of the LEAQ as a screening tool for children aged between 25–36 months, norm data was collected from (N=114) babies for the Lingala version and (N=82) babies for the Kiswahili version. In order to determine the Kiswahili version, AAST norm data were collected from N=123 (male: n=62, female: n=68). A secondary research design was used to collect data from pre-existing literature from various available sources such as: Google Scholar; PubMed; BioMed Central (BMC); the American Speech-Language-Hearing Association (ASHA), Health Inter-Network Access to Research Initiative (HINARI) and WHO websites; and many other open access and peer-reviewed international journals, to enable a review of a broad body of literature on the role of the CBR programme in promoting ear and hearing health services at the community level.

Results

The results for the regression curve generated with age as an independent variable and total scores as dependent variables for the LEAQ showed the Kiswahili version as being very similar, r=0.81 (p=< 0.001) to the original German version r =0.91, and the Lingala version as being a little different but also very similar to the German version, r= 0.77 (p=< 0.001), whereby a value of 0.7 or higher shows a high correlation .These results legitimize the use of the LEAQ to screen for hearing loss in the DRC in infants and children from 1-24 months and

above. The constructed version of the version of the Kiswahili Adaptive Auditory Speech Test (AAST) was used to find out the Speech Reception Threshold (SRT) in quiet and in noise conditions with the aim to determine the norm values in children aged 3-4 years and older.

Conclusion

The adapted Lingala and Kiswahili version of the LEAQ can be used for the screening and diagnosis of hearing loss in children under and over 3 years in the DRC. The study confirms that, the Kiswahili version of the AAST has an approximate difference of 10.2 dB observed between the year 4 old and 10 years old children in quiet, with a significant improve as the age increase. In addition, the LEAQ and the AAST can be used as screening tools in infants, but it may also be important to point out that, despite the UNHS being the gold standard , the procedures for these other 2 tests will represent an approximation if the UNHS cannot yet be introduced in the DRC due to cost and organizational reasons. This can have a positive implication by generating concrete data that will have considerable impact in influencing the legislation and integration of the LEAQ as a screening tool in the primary health care package.

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Abbreviations

AABR: automated auditory brainstem response

AOE: acoustic otoemissions

AAST: Adaptive Auditory Speech Test

ABR: auditory brainstem response

ANOVA: analysis of variance

ASHA: American Speech-Language-Hearing Association

BELLS: Battery for the Evaluation of Listening and Language Skills

CAC: Community Awareness Unit

CBM: Christian Blind Mission

CBR: Community-Based Rehabilitation

CBRW: community-based rehabilitation worker

CHW: Community health worker(s)

CMV: Cytomegalovirus

CP: cerebral palsy

dB: decibel(s)

EARC: Education Assessment and Resource Centre

ENT: ear, nose and throat

HCI: Human Capital Index

HI: hearing impairment

HL: hearing loss

IBM: International Business Machines

LEAQ: LittlEARS Auditory Questionnaire

LMIC: low- and middle-income countries

NBHS: newborn hearing screening

NCHAM: National Centre for Hearing Assessment and Management

NGO: non-governmental organization

NHS: neonatal hearing screening

NIS: National Institute of Statistics

OAE: otoacoustic emissions

OME: otitis media with effusion

PCHL: permanent childhood hearing loss

PDHI: Prevention of Deafness and Hearing loss

PHC: Primary Health Care

PNRBC: National Programme of Community-Based Rehabilitation

PWD: people with disabilities

SD: standard deviation

SPL: sound pressure level

SPSS: Statistical Package for the Social Sciences

SRT: speech reception threshold

UK: United Kingdom

UNHS: universal newborn hearing screening

VHW: village health workers

WHO: World Health Organization

WSW: weak-strong-weak

WWS: weak-weak-strong

CHAPTER ONE: INTRODUCTION

1.1 Perspective of hearing care in developing countries

Developing countries have many different characteristics including a larger rural population, qualified as those with a low average annual income of less than $10,065 (USD) per person; a low industrial component and are often dependent on aid from other developed countries; linguistic diversification; and greater income inequality than people living in developed countries (McPherson, 2012).

Referring to these characteristics, many children with hearing loss go undetected over time and most of the population in developing countries have difficult accessing audiology services, even though audiology continues to progress in the industrialized world by offering people with hearing loss screening, diagnostic evaluation, hearing aid fitting and proper rehabilitation (Brouillette, 2008). Additionally, hearing loss does not appear to be a top priority for people in developing countries facing issues of political instability, nutritional deficiencies, inadequate maternal and prenatal care, and other life-threatening health issues (McPherson, 2008).

1.2 Facts about the Democratic Republic of the Congo (DRC)

The DRC is located in central Africa, straddling the equator with an area of 2,345,409 km². Under the 2006 constitution, the DRC is made up of the city of Kinshasa and 25 provinces. The country has 96 cities, 145 territories, 471 sectors, 261 chiefdoms, 337 urban communes, 267 rural communes and 5,397 groupings. Recent projections by the National Institute of Statistics (INS, 2020) place the Congolese population for the year 2019 at 97,356 million inhabitants, with a density of 36 inhabitants per km², and a fertility estimated at 6.6 children per woman (EDS, 2014; INS, 2019), and an annual population growth rate of 2.9% (INS, 2015, 2017).

Despite the growth of the population, social and human indicators are weak. In 2018, the infant mortality rate of 68.2 per 1,000 live births was higher than the Sub-Saharan average of 52.7, and the country is ranked 146th out of 157 countries in terms of the Human Capital Index (HCI) (World Bank, 2020). The DRC is at a low state of development and its economic and political conditions places it in a fragile position with a significant risk of a future humanitarian situation. According to a number of non-governmental organizations (NGOs) the current level of economic and political instability gives the DRC a high degree of vulnerability to a humanitarian disaster. This, in turn, jeopardizes health and social development endeavours (OCHA, 2018a; World Bank, 2017; DIPR, 2018).

1.3 Risk factors for hearing loss in infants and children in the DRC

There has been some progress in improving the healthcare system, which has been supported by international organizations. However, many children in the DRC die before the age of 5 due to preventable or treatable diseases. For those that survive, some of these causes of death are also serious risk factors for hearing loss. Leading causes of death are:

1. Malaria, where around 16.5 million cases were reported in 2019.

2. Measles, where cases surged in 2019–20, to reach 332,000 nationwide, making it the worst outbreak in the DRC's history (UNICEF, 2020), with more than 6,200 recorded fatalities and around 85% of these were children under the age of 5.

3. Meningitis has been one of the serious infections affecting children and can cause hearing loss. DRC is among the countries situated on the meningitis belt (Bwaka et al., 2019).

4. HIV / AIDS. Children who are affected with these sometimes have low resistance to infections that weaken their immunity leading to greater risks of infection, such as

cytomegalovirus (CMV) (Ross & Fowler, 2008), which is one of the major causes of hearing loss in children globally.

5. Low birth weight. In earlier research (Cristobal & Oghalai, 2008) observed that the prevalence of failed hearing screening in neonates with low birth weight is significantly higher than in neonates with normal birth weight, because those with low birth weight experience higher rates of transient middle ear fluid accumulation and conductive hearing loss.

6. The health of pregnant women is crucial for the well-being of the baby. It is important that pregnant women have enough good food and access to health care. A baby can be born with hearing loss because the mother was sick or gave birth to a child with low birth weight, which is among the risk factors associated with hearing loss. Moreover, some infections can be passed from mother to baby during pregnancy and damage the baby's hearing. These infections include rubella (German measles), tuberculosis, CMV and syphilis (de Goffau et al., 2011; Cristobal & Oghalai, 2008).

7. Malnutrition remains a challenge and persistent problem for Congolese children, with about 46% of children suffering from stunting (Centre for Disease Control and Prevention, 2007). Almost half of children under the age of 5 suffer from chronic malnutrition, which results in long-term health problems that can affect even subsequent generations, as poor nutrition may predispose children to malaria infections and thus, anaemia, by impairing the immune function. Some 2 million children in the DRC suffer from severe malnutrition (USAID, 2017; UNDP, 2015; UNICEF, 2018; RD Congo, 2014; OCHA, 2017) and several studies (Jung et al., 2019; Kamel et al., 2016; Schieffer et al., 2017; Lemajić-Komazec & Abenavoli, 2018; Olusanya, 2011), have reported an association between malnutrition and hearing loss from conductive deafness to sensorineural hearing loss.

Several interventions in response to these risk factors for hearing loss have been put in place by the Ministry of Health in the DRC together with NGOs. This has been in the areas of promotion and prevention through the availability of vaccines, as well as in the therapeutic context in dealing with ear infections in newborns and infants. However, no action for early detection and appropriate interventions following detection have existed or exist within the framework for the prevention of deafness and hearing loss in order to reduce the morbidity linked to hearing loss (WHO, 2018).

This gap is behind this study in the development of a tool for the early detection of children at risk of hearing loss. It is hoped this will constitute an important first step, which will need to be integrated into the primary health care system in response to the consequences of diseases and factors leading to deafness.

1.4 The global status of ear and hearing care and the Democratic Republic of the Congo

For the last 25 years, there has been a growth in the global estimates of disabling hearing loss. In 1985, the WHO estimated that 42 million people in the world were living with disabling hearing loss (Smith, 2003; WHO, 1995). This number increased to 120 million in 1995 and to 278 million in 2005, which was approximately 4.2% of the world's population (Olusanya, 2007. In 2011, this estimate increased to 360 million persons with disabling hearing, loss representing 5.3% of the world’s population (WHO, 2012; Stevens et al., 2011). Recently, the WHO estimated that there are 466 million persons in the world with disabling hearing loss representing 6.1% of the world's population, among them 34 million (7%) of these are children (WHO, 2018). Based on a 2012 WHO report, approximately 7.5 million of these children were under the age of 5 years (Neumann et al., 2019).

According to the National Statistical Bureau DRC (INS, 2017), 19.5 % of the population are children aged 0–4, which is about 18 million people. Considering the projections by the National Statistical Bureau DRC (INS, 2019–2020) for the year 2020, an estimate of about 19.9 million of the children are aged 0–4 out of the global population of about 102 million children in 2020. Considering the global prevalence of hearing loss estimated by the WHO of 6.1% (WHO, 2018), it is possible that about 6.2 million of the people in the DR Congo have disabling hearing loss and among them about 435,200 (7 %) are children.

In earlier studies, Mulwafu et al. (2015) and Olusanya et al., (2014) indicated that for children aged between 5 and 14 years, the prevalence was estimated at 1.9% in sub-Saharan Africa versus 0.4% in high-income countries. However, this estimation for Africa was based on a limited evidence base, and most of the available studies relied on school-based hearing screenings. The story so far around prevalence rates is that estimates vary wildly but have increased over the years as measurement accuracy has improved, but for the DRC, as with other African countries, the data are still unreliable.

1.5 Services for hearing screening in the DRC

1.5.1 Audiology services

There is a severe shortage of audiologists to provide audiological services to children in developing countries (Mulwafu et al., 2011). In the DRC there are only 2 trained audiologists serving a population of about 85 million. The ratio of audiologists to hearing-impaired in the DRC is about 1:2.600,000 and the ratio of audiologists to the entire population of DRC is about 1:42.500,000. This has serious implications for audiological service provision to children with auditory disorders in the country.

1.5.2 Hearing Screening in educational settings for children with hearing loss

In the DRC, about 80 centres and schools for people with hearing loss exist, and around 140 teachers (MoH – DR Congo, 2012). Byaruhanga et al. (2015) found that 85% of teachers for learners who are deaf and hard of hearing in the DRC were diploma holders in general or regular education, with basic notions about education for learners who are deaf and hard of hearing. As for the audiology service, until 2013 no audiology centre or Education Assessment and Resource Centre (EARC) existed in the country. The first audiology centre was established in Aru, in the north of the DR Congo by Ismael Byaruhanga, as one of the services of the Centre for Education and Community-Based Rehabilitation (Byaruhanga, 2019). With just one centre, this means that the vast majority of the schools or centres for the deaf do not benefit from the educational audiology service.

1.5.3 Hearing screening services in the health sector

Early detection, assessment, rehabilitation and placement are indispensable prerequisites for the successful development and integration of a child at risk of hearing loss. This was the major aim behind the EARC initiative in Kenya and Uganda, although unfortunately, these centres had many challenges to sustain themselves, because they were funded by the temporary funding from NGOs (MoEST-Kenya, 2003; Terres des Hommes, 2007; Lule & Wallin, 2010; Ndurumo, 1993).

In the DRC, there is a National Programme of Community-Based Rehabilitation (PNRBC) which is integrated into the Ministry of Health. It houses activities related to the prevention of deafness and hearing loss (PDHI) and combines ear, nose and throat (ENT), audiology and speech and language therapy. The division also works closely with other specialized structures such as ophthalmology, which has its own national programme and orthopaedic services for early identification and referral (MoH –DR Congo, 2012).

The government of the DRC has a decentralized health facility in accordance with primary health care standards. This is characterized by the presence of health centres as the first-level care facility, a compulsory structure at the level of a health zone, with the role of bringing care closer to the communities; serving as a structure of first contact of the population and to provide a minimum package of care activities according to national standards (MoH – DR Congo, 2006).

Furthermore, at the health centre, there is a community-based service called the Community Awareness Unit (CAC) that incorporates community health workers, community links and community-based workers. Therefore, the available services are the Community Awareness Unit, and other services like the Preschool Consultation Programme and the CBR. This offers a great opportunity to provide an ear and hearing health service to the population of the DR Congo through a bottom-up approach.

Following the Declaration of Alma-Ata's recognition of rehabilitation as an appropriate strategy to improve access to rehabilitation services for people in their communities, the transfer of basic rehabilitation skills from professionals to teachers, PHC workers and less-specialized practitioners, could work very well in the DRC. Wade (2003) suggested that rehabilitation is more effective when given in the patient's own environment. Furthermore, Turmusani et al. (2002) state that promoting ear and hearing through CBR should maximize and improve access to service provision in audiology in education settings. Lastly, Lorenzo et al. (2015) argued that community-based workers are in an ideal position to assist in providing critical support to people at risk of neglected conditions in these areas.

1.6 Implications of hearing loss

Several years ago, the WHO decided that a person with hearing loss had a disability. In the original nomenclature, a disability was a loss of function imposed by a loss of the auditory system, such as inability to understand a conversation. A handicap was the social or vocational consequence of a disability, such as having to change jobs because one could no longer perform the requisite responsibilities. According to the WHO (2001), disability arises from an individual's hearing loss, physical and social environments, and individual qualities, such as personality and intelligence. This means that a person with hearing loss needs to be considered in terms of their activity limitations and participation restrictions. The activity limitation varies by individual. For some it may mean an inability to participate in a group conversation. In other cases, the effect can be broader in scope, for example, a person may avoid group interactions altogether (Tye-Murray, 2009).

The effect of hearing loss on an individual can be dramatic. In addition to creating difficulties associated with basic receptive communication, a hearing loss often produces difficulties in other important areas, such as expressive communication, educational challenges, psychosocial adjustment, mental development, and economic issues (Davis et al., 2019 & Joint Committee on Infant Hearing, 2007). Of all the obstacles that people with hearing loss face, communication difficulties are among the most consequential.

Moreover, even newborns with a functioning hearing system perceive auditory stimuli. That is to say, the auditory mechanism is the channel through which we acquire a receptive and spoken language and this constitutes the start of language acquisition. Therefore, the lack of good hearing function has effects on the perception and production of language. It is on the basis of this observation that hearing assessment is considered crucial.

According to Tye-Murray (2009), the lack of good hearing function leads to the formulation of the objectives of the hearing rehabilitation plan, that is to minimize the impact of hearing

loss through the provision of devices. Besides this, lifestyle can have a major effect on participation restrictions. From this perspective, the objective is to identify the effects of the person's restriction of participation in their daily life. If the restrictions experienced by an individual are great, the person may withdraw from lifestyle activities.

Despite the effects of hearing loss on the child's life and education as indicated earlier, this research goes further by focusing on the key aspect, that of early detection, which must precede the rehabilitation plan, as an important step that seems to be ignored in developing countries mostly due to lack of information by the parents. Even if the follow-up services are under-developed or do not exist, as is the case in the DRC, through the first screening results, parents can benefit from knowing early the status of their child's hearing behaviour and can modify their communication style to facilitate essential effective parent-child interactions (Davis & Carr, 2014).

1.7 Challenges and importance of early detection of hearing loss in the DRC

Several studies (Galhotra et al., 2019; Tomblin et al., 2014; Wake et al., 2005) have shown that infants who are identified early and who receive intervention before the age of 6 months have better school outcomes, and improved language and communication skills by ages 2to 5 years. In a recent study, Neumann et al. (2019) demonstrated key conditions for the effectiveness of the NBHS, which has been a topic of debate for decades (WHO, 1995). A newborn and infant hearing screening programme is one strategy to ameliorate disabling hearing loss. WHO resolutions regarding the prevention of deafness and hearing loss have been adopted (WHO, 2018), which encourages member states to implement screening programmes for early identification of ear diseases and hearing loss in babies and young

children. So far, however, there is a lack of such a comprehensive programme in many middle- and low-income countries, including the DRC.

Given the risk factors associated with hearing loss in the DRC and the possible growing burden of disabling hearing loss, this study aims at developing the first hearing screening tools for infants and children and promoting ear and hearing health through CBR approaches in the DRC, in areas of the country where there is no NBHS. The hearing screening tool will include: the adaptation of the LEAQ in Lingala and Kiswahili, a simple tool that a mother can use to evaluate the auditory behaviour of a child from 0–24 months (Coninx 2004) and the AAST (Coninx, 2004; 2005), as a screening and diagnostic tool which will be adapted in Kiswahili, one of the national languages in th DR Congo .

1.8 The three objectives and their interdependency

This study has 3 objectives:

Objective 1: To adapt and evaluate the effectiveness of the LEAQ as a screening tool for hearing loss in children aged 0–24 months in the DRC.

Objective 2: To construct, and validate the Congo Kiswahili versions of the AAST for children aged 3–4 years and older.

Objective 3: To determine the role and effectiveness of the LEAQ and the AAST as hearing screening tools in the CBR programme.

Each objective has a major research question and sub-questions to address the research concern. The 2 tools, namely the LEAQ and the AAST, fall into the category of tools for early detection, assessment, and diagnosis of hearing loss (Coninx, 2004). They have been chosen because they are simple to use and adapted to different cultures. The use of these tools

is possible at the primary level by community agents, CBR agents, community relays and parents for the early screening of children with hearing loss. At a secondary level, they can be used by nurses, midwives, specialized teachers in schools for the deaf, and at the tertiary level for example, ENT, paediatricians, psychologist as tools for early screening and also, in the case of the AAST, as a diagnostic tool.

In this research study the first 2 objectives will be aimed at developing these tools which are of great importance in the early detection of children at risk of developing hearing problems. The study will promote the role of CBR as one of the health components in the DR Congo – a country with its decentralized primary health care system. According to the WHO (2011), around 90% of the world's hearing-impaired children live in countries where limited resources are likely to present a significant challenge to the implementation of the NBHS.

The integration of the LEAQ and AAST as hearing screening tools into the CBR programme is novel in the DRC because of the existing health structures and patterns of care. Therefore, this research will attempt to use these tools at the primary level as an alternative method to match the methods of the NBHS (WHO, 2010; Kennedy, McCann, Campbell, Kimm & Thornton, 2005; National Institutes of Health, 1993; National Deaf Children's Society, 1994). The NBHS does not yet exist in the DRC and requires equipment and qualified personnel for implementation that the DRC does not have (Neumann, 2019).

1.9 Outline of chapters

This thesis is set out in 5 chapters. The first chapter gives a general overview of audiology service provision in educational settings and in the health sector, an overview of the status of ear and hearing care and the prevalence, causes and burdens of hearing loss in everyday life. In addition, this chapter describes the situation regarding NHS programmes in the country, the resources available for the provision of audiology services and also the challenges associated with early detection of hearing loss.

Chapter two focuses on the development and adaptation of a hearing behaviour test for children, called the LEAQ, into 2 national languages: Lingala and Kiswahili, based on a questionnaire which describes hearing development conditions for a normal child.

Chapter three focuses on the development and adaptation of the AAST, adapted into Kiswahili language. In addition, this chapter describes the evolution of the AAST in time and space, its cultural consideration in a multicultural and multilingual country like the DR Congo and its applicability. Chapters 2, 3 and 4 each contain the objectives of the dissertation, the research questions, a description of methods used in collecting and analyzing the data and the results are stated.

Chapter four focuses on CBR, as a strategy for promoting audiology services for children by involving their parents, families and community institutions, such as schools and hospitals. This chapter also describes the principles of CBR and the specificity of this strategy as a successful and suitable model for delivering services to children with hearing loss from 0 to 12 years old.

Chapters five and six contain the summary of the strong outcomes of the study, a global conclusion and the limitations of the study, as well as future research and final

recommendations for the applicability of the LEAQ and the AAST in the primary health care package for the promotion of ear and hearing care in the DRC.

1.10 Summary

It is a globally accepted fact that developing countries have different characteristics, including a larger rural population and a low industrial component, and often dependent on aid from other developed countries, and have more linguistic diversification and greater income inequality than people living in developed countries (McPherson, 2008). Because of these characteristics, many children with hearing loss are most likely to go undetected in time, even though audiology continues to progress in the industrialized world by offering people with hearing loss screening, diagnostic evaluation, hearing aid fitting and proper rehabilitation (McPherson & Brouillette, 2008).

In the DRC, infants and children face many risk factors which include malaria, measles, meningitis, HIV/AIDS, low birth weight, malnutrition and the risk of being born to unhealthy mothers. This puts them in a very vulnerable state and makes them susceptible to hearing loss. Hearing loss can have devastating and far-reaching consequences, like difficulties associated with basic receptive communication, expressive communication, educational challenges, psychosocial adjustment, mental development and an inability to participate in group conversations.

This study was aimed at the development of a tool for the early detection of children at risk of hearing loss and how it can be integrated into the primary health care system as an alternative measure to the UNHS.

This attempt in developing the first hearing screening tool is hoped to result in the reduction of the severity of shortages in audiological services in the DR Congo and provide parents

with the right information about the hearing state of their children to allow them to make the right health decisions for their children.

CHAPTER TWO: LittlEARS AUDITORY QUESTIONNAIRE FOR CHILDREN: A SCREENING TOOL

2.1 Introduction

The ability to measure the auditory behaviour of a child who has normal hearing or is at risk of hearing loss in his or her usual environment is of particular importance, not only for providing timely guidance in the area of hearing rehabilitation, but it also contributes as part of early identification. Stevens & Parker (2009) reported that in the absence of effective early hearing screening, detection of permanent hearing loss in children can be delayed by 2 to 3 years.

2.2 What is screening?

The WHO (2020c) define the screening as a brief and simple procedure used to identify infants and young children who may be at risk for potential health, developmental, or socio-emotional problems. Screening helps to identify children who may need a health assessment, diagnostic assessment or educational assessment. 'Screening' means the use of a standardized instrument, such as a parental questionnaire or observation that has been validated by research to learn more about the development of the child. The purpose of screening is to identify people from an apparently healthy population who are at higher risk of a health problem or condition, so that treatment or early intervention can be offered.

Medical screening has been around for about 60 years and has a very rich history (Morabia & Zhang, 2004) and has been a major component of modern medicine and public health. In addition, a number of clinical tests that assess hearing skills in hearing-impaired children have been developed, largely as a result of research and clinical developments in the field of cochlear implants (CI) (Kessler, Giolas & Maxon, 1990; Anderson & Smaldino, 1998; 2002; 2012; Anderson & Matkin, 1996; Cox, Alexander, 1995; Zimmerman-Phillips, Robbins & Osberger,

2001; Robbins, Renshaw & Berry, 1991; Purdy, Farrington, Moran, Chard & Hodgson, 2002; Bzoch & League, 1991; Fenson et al., 2007; 2000; Rossetti, 2006; Grimm & Doil, 2000).

Despite the advantages and statistical integrity of these various auditory-related subjective behaviour tests, there is some evidence that results obtained in this manner may not relate well to reports of child behaviour in a structured framework. This includes the time required to complete the questionnaire and the requirement that the parent be literate and appears to limit their applicability in many research, clinical and educational settings (Bagatto et al., 2011). These limitations may have a negative impact on the results of screening among children in developing countries like the DR Congo, especially in rural areas where the literacy rate is low, and UNHS has not yet been implemented (MoH – DR Congo, 2015).

Besides this, most of these tools have been evaluated based on conceptual clarity, standards and measurement models, especially accessible language adaptation (Bagatto et al., 2011). However, the LEAQ received an 'A' grade on the conceptual clarity area and the conclusion by Coninx et al. (2009) & Bagatto et al. (2011) was that the LEAQ is a good outcome evaluation tool because of its alternative ways of administration, and other criteria, such as not presenting any bias in either the items or the instrument, the responses must not be contaminated by cultural differences or social circumstances and the tool must have internal consistency, validity and sensitivity as well as be usable in clinical practice were mentioned (Offei & Coninx, 2014; Rauhamäki et al., 2014; Graham et al., 2006; Andresen, 2000).

Table 1: Characteristics of some questionnaires developed for subjective evaluation of children with hearing loss since the 1970s

Questionnaire	Purpose of instrument	Target population	Skills needed for administration	Number of items	Sources
HPIC	Develop a personal profile of difficult academic situations	Hearing-impaired school-aged children 8–14 years	Child complete	31	Kessler, Giolas & Maxon (1990)
LIFE Student Appraisal and LIFE Teacher Appraisal	Identify classroom situations that present listening challenges/ Assess children listening in the school setting	Hearing-impaired school-aged children (8+)	Child or Teacher completes (child/Teacher version)	15=Child 16=Teacher	Anderson & Smaldino,(1998; 2002; 2012)
SIFTER and Preschool SIFTER	Identify school-aged children at risk of educational failure (academic attention, communication, participation, behaviour)	Hearing-impaired school-aged (SIFTER) and preschool (3 years, kindergarten children)	Teacher completes	15 originated from a 25-item questionnaire	Anderson & Matkin (1996). redesigned (2011)
Children's APHAB	Measure hearing aid benefit for quiet and difficult listening situations and aversiveness of sounds	Hearing-impaired children older than 9 years	Child or parent completes (child/parent version)	24 unaided and 24 aided (48 total); initially 66-item inventories that are completed by a hearing aid wearer	Cox & Alexander (1995)
MAIS and IT-MAIS	Evaluate meaningful use of sound in everyday situations (device use, environmental sounds speaker discrimination)	Profoundly deaf children (IT-MAIS is preschool version)	Clinician interviews parent and performs rating based on parental report	10	Zimmerman-Phillips, Robbins & Osberger (2001); Robbins, Renshaw & Berry (1991)
ABEL	Evaluate Auditory Behaviour in Everyday life (auditory awareness, aural/oral and social skills)	Mild-profound hearing loss: 4–14 years	Parents complete	24 in short version (or 38)	Purdy, Farrington, Moran, & Hodgson (2002)
The *Receptive –Expressive Emergent Language Test–Fourth Edition* (REEL-4)	Identify infants and toddlers who have language loss or who have other disabilities that affect language development	**Ages:** Birth through 36 months	Parental observations of child behaviour; individually administered	Examiner's Manual 25 Profile/Examiner Record Booklets	Bzoch & League (1991)
The MacArthur Communicative Development Inventories	Parent report instruments for assessing communicative skills in infants and toddlers	18–30 months	Parental observations	Level I, (for 8–18-months) contains an 89-word checklist for vocabulary, Level II, forms A and B (for 16–30-months) each contain a 100-word vocabulary	Fenson et al. (2007; 2000)
The Rossetti Infant-Toddler Language Scale	Identifies preverbal and verbal language development problems in infants	Ages Birth to 3 years	Examiners with a thorough knowledge of child development and communication skills or behaviour report by parent or caregiver	Test kit: Examiner's Manual, 15 Test Forms	Rossetti (2006)

(ELFRA) Parent questionnaires for the early detection of children at risk	Identify children at risk of a language development disorder	At the age of 12 and 24 months	Parental observations	Test complete consisting of manual, 5 questionnaires ELFRA 1, 5 questionnaires ELFRA 1 short version, 5 questionnaires ELFRA 2, 5 questionnaires ELFRA 2 short version, 5 evaluation sheets ELFRA 1 / ELFRA 2, 5 evaluation sheets ELFRA 1 / ELFRA 2 short version, 5 parent information sheets U6, 5 parenting information sheets U7	Grimm & Doil (2000)
The LittlEARS Auditory Questionnaire	Assess the auditory behaviour of normal hearing children and hearing-impaired children who receive a cochlear implant or hearing aid	Children with normal hearing between 5 days and 24 months of age	Parents of children with normal hearing	35 items	Coninx F et al., (2009)

2.3 Parental and family Support for auditory behaviour evaluation

Hardman, Drew & Egan (2011) state that some conditions, such as spina bifida and Down syndrome, are readily apparent at birth, whereas others, such as hearing loss, are not immediately identifiable. In most cases, if a child's loss is identified, the mother often becomes primarily responsible for relating to the child and attending to his/her needs. Evidence clearly indicates that the family's ability to adapt to the child's hearing loss could be hindered by the lack of information about available services (Mukuria & Eleweke, 2010).

Lacking information, support and knowledge make many parents unable to make appropriate choices about the communication avenues and educational needs of their children. The role of parents, particularly of mothers and families of children with disabilities, is vitally important for a community-based approach in working with children. Mothers in general are often the main caregivers and also become the key persons to ensure services and programmes reach their children.

In addition, the tools used to monitor and assess children's auditory development, such as parental questionnaires, are more developed and accessible in the West (Kessler, Giolas & Maxon, 1990; Anderson, & Smaldino, 1998; 2002; 2012; Anderson & Matkin, 1996; Cox & Alexander, 1995; Zimmerman-Phillips, Robbins & Osberger, 2001; Robbins, Renshaw, & Berry, 1991; Purdy, Farrington, Moran, Chard & Hodgson, 2002; Bzoch & League, 1991; Fenson et al., 2007; 2000; Rossetti, 2006; Grimm & Doil, 2000).

The hearing assessment questionnaire such as the LEAQ, which has been adapted to social and cultural contexts, is generally available in more than 20 languages worldwide, of which around 90% are in official European languages (Coninx et al., 2009; Neumann et al., 2012; Coninx, & Schäfer, 2012 ; Schäfer, 2013; Obrycka et al., 2009; May-Mederake et al., 2010; Bagatto et al., 2011; Wang et al, 2013; Schaefer, Coninx & Fischbach, 2019; Geal-Dor et al., 2011; Ezzeldina, Kaddah & Hameed, 2018; Weichbold et al., 2005; Negro, García & Quevedo, 2016; Persson et al., 2019).

To date, the LEAQ has been adapted only in Ghana in 3 Akan languages: Fanti, Akwapen and Asante (Offei and Coninx, 2014). Consequently, there is a lack of these tools in other languages, especially in African languages with many speakers (for example, the Kiswahili language in the DR Congo). Similarly, parent questionnaires have been shown to be an effective and cost-efficient tool for hearing screening in infants aged up to 24 months (Schaefer, Coninx, & Fischbach, 2019). With the gradual evolution of audiology services in some African countries, in particular the DR Congo (Byaruhanga, 2019) where thousands of infants and children are confronted with hard conditions / factors favouring hearing problems, the development and adaptation of the LEAQ is of critical importance. Its implementation through a CBR approach as a cost-efficient tool can achieve greater output, determine the value of the LEAQ as a community-based early hearing detection tool and is also a tool for clinical utility for intervention of permanent childhood hearing loss (PCHL).

2.4 The LittlEARS Auditory Questionnaire

The LEAQ was developed to assess the auditory behaviour of normal hearing children and hearing-impaired children who receive a cochlear implant or hearing aid prior to 24 months of age (Coninx et al., 2009; Tsiakpini et al., 2004, Copyright MED-EL, 2004; Coninx, 2004). The LEAQ is formed of 35 items designed to be responded by parents or caregivers to assess the auditory development during the first 2 years of hearing in the real world and exploit receptive and semantic auditory behaviour, as well as expressive-vocal behaviour.

The questions are listed in order, based on age and are in a yes / no format. The total of all 'yes' responses provide a score that can be compared to the average and minimum values depending on age. These values are provided by 1-month age groups based on normative data (Coninx et al., 2009). The mode of administration is not affected by either, under professional direction or independently.

It has been suggested that the use of an early caregiver observation tool may be useful for health professionals, CHWs, CBRWs involved in primary ear and hearing care. As hearing loss affects not only the individual but also the whole family and society in general (WHO, 2012), the interest in developing and adapting this LEAQ tool in Lingala and Kiswahili for the DRC is part of the initiatives of this research, to answer the needs created by hearing loss. To be more effective, this tool aimed at assessing the auditory behaviour of normal hearing children and hearing-impaired children, needs to be integrated into a CBR as one of the components of primary health care.

2.5 Adaptation of the LEAQ in the Lingala and Kiswahili versions

The Democratic Republic of Congo is one of the most linguistically diverse countries in the world, with over 200 languages spoken in the country. While French is the official language and widely used in education and government, there are 4 national languages: Kikongo, Lingala, Swahili and Tshiluba (DR Congo, 2015). The distribution of speakers for each of the 4 national languages is mostly clustered in 4 parts of the country. Lingala has about 14 million speakers and is more widely spoken in the northwest, and Swahili with about 22 million speakers is more spoken in the east. The adaptation of the LEAQ in these 2 languages can be beneficial to about 36 million speakers, which is almost the population of Poland in Europe (World Atlas, 2021). The marked map below shows the distribution of speakers of Lingala and Swahili in the country's territories.

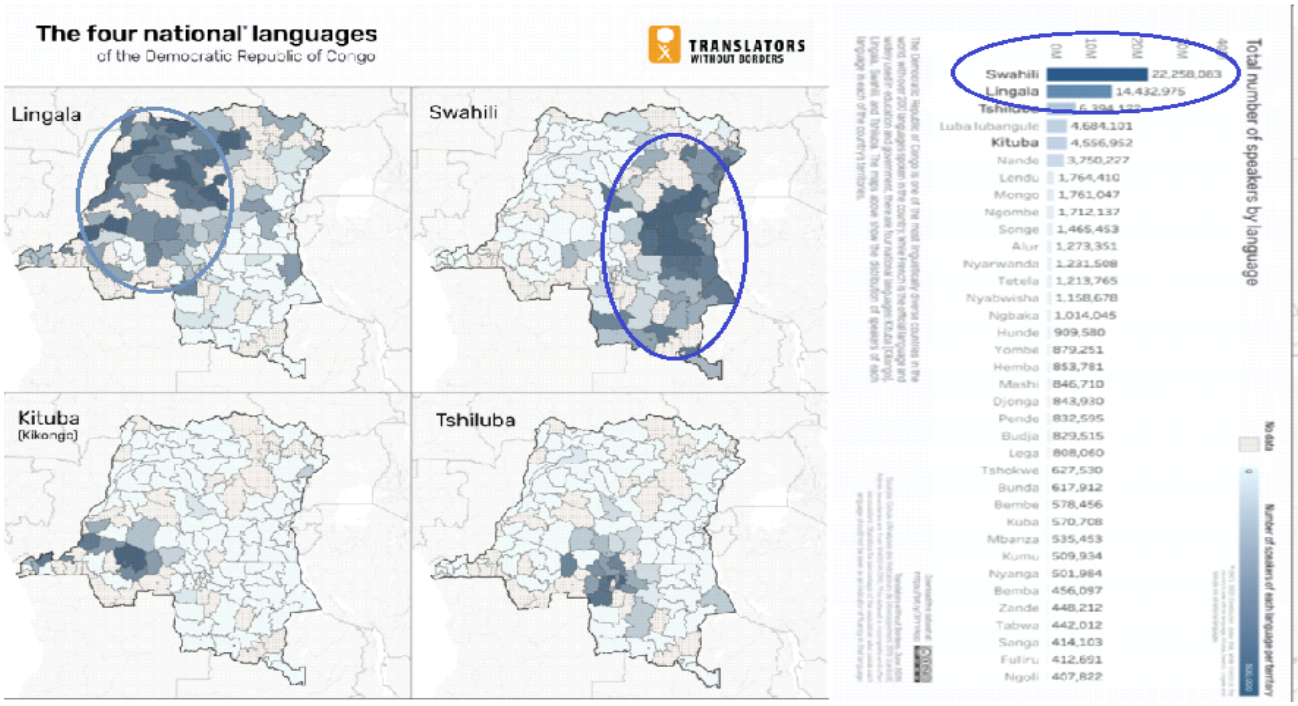


Fig. 1: Map of the distribution of speakers of Lingala and Swahili in the DRC *(Translators without Borders, 2021)*

2.6 Objectives and research questions

2.6.1 Objectives

To adapt and evaluate the sensitivity of the LEAQ as a screening tool for hearing loss in children aged 0–24 months in the DR Congo.

2.6.2 Main research question

To what extent can the LEAQ be adapted and defined as a hearing screening tool for children aged 0–24 months in the DRC, where there is no NBHS programme?

Six sub-questions have been formulated to answer the main question:

1. Are there correlations between the age dependency norm values of auditory skills for the LEAQ Lingala and Kiswahili versions and the original German version?
2. Is there a difference between the auditory behaviour observed by respondents in urban (town) and rural areas (village)?
3. Is there a difference between the auditory behaviour observed by respondents who are mothers (biological) and others (father, siblings, grandmother and caregivers)?
4. Are the responses of mothers and caregivers depending on the educational level?
5. How appropriate is the LEAQ as a community-based screening tool in detecting auditory deficiency in children aged 0–24 months?
6. How sensitive is the LEAQ as a community-based screening tool in detecting auditory deficiency in children aged 25–36 months?

2.7 Methodology

The LEAQ was originally developed in German (Coninx et al., 2009), meaning that the original version is considered as a basis for any adaptation to other languages. For this research, the English (UK version) as the first translation from the original German version was used. The procedures included:

• identification and selection of the translators

• translation from the English version into Lingala and Kiswahili

• back translation, meaning translating from the Lingala and Kiswahili versions to English

• 5 days training of field assistants and testing the administration methods

• identification of sites: random selection of 4 out of 7 health zones with paediatric services in North Ituri

• contact with the health zones' medical officers, general referral hospitals and local administration leaders.

Pre-Testing and readjustment were done especially for the Lingala spoken in the northern part of the DRC (in the Haut- and Bas-Uélé Provinces) originally called 'Bangala', to Lingala spoken in the western part. The same procedure was done for the Kiswahili spoken in the eastern part of the DR Congo (Ituri/Bunia Province) to the Kiswahili spoken in the southeast (Goma-Bukavu-Lubumbashi).

2.8 Data collection procedure

The LEAQ was administered to caregivers with normal hearing children who were mostly biological mothers, siblings and grandparents, during the regular immunization days, and also caregivers in the paediatric wards. Caregivers with no education level were aided by professionals. Ethic approval for the study was obtained from the Provincial Ministry, Health Divisions.

The inclusion criterion for subjects in this study was ages 0 to 24 months (Coninx, 2004). Data was collected from a total of 723 babies for the Lingala version and 648 babies for the Kiswahili version. In order to investigate the effectiveness of the LEAQ as a screening tool for children between 25–36 months, data were collected from a total of 114 babies for the Lingala version and 82 babies for the Kiswahili version.

2.9 Statistical analysis

Scale analysis (Pearson's correlation coefficient) was used to determine the correlation between the total score and age of the children and quantitative data were presented as mean (M) and standard deviation (SD). A regression analysis was done with age as independent variable and the total score as dependent variable; this helped to generate a normal curve with standardized values. Correlation analysis was used to determine differences between categories by education groups. In order to compare the impact of education level on the LEAQ score, a one-way ANOVA was used. All the data that were analyzed with Statistical Package for the Social Sciences (SPSS) version 20 and statistical significance was set to $p<0.05$.

2.10 Results and interpretation

The results are presented based on the 6 sub-questions emanating from the main research question of objective one.

In an earlier study, Coninx et al. (2009) suggest that the equal number of children from each language, as well as from an equal number of children at each age interval within the sample, could be one-way to improve studies about the LEAQ. In this study, the histogram is used to give a clear view of the data distribution and the spread of values of the data as well as for spotting outliers (Nuzzo, 2019).

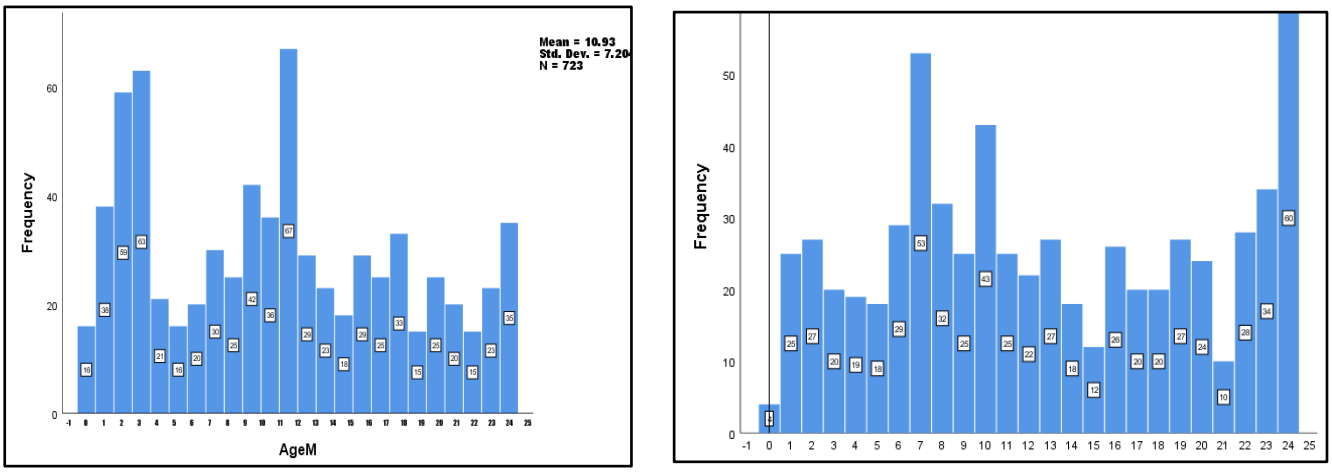
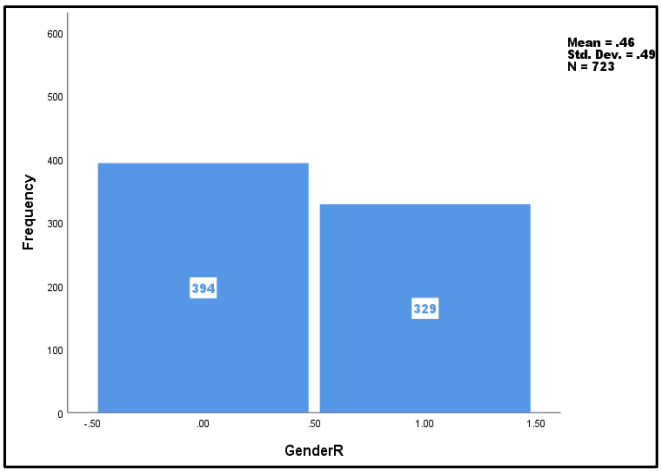


Fig. 2: Age distribution in months for Lingala and Kiswahili *Lingala N=723, Kiswahili N=648*

The histogram (figs 1 and 2) shows that about 85% of the age interval have almost an equal number of children and the standard deviation for both the Lingala version (mean 10.93 and SD 7.20) and the Kiswahili version (mean 12.72 and SD 7.25) fall between the range of values that is reasonably expected to occur. This applies as well to figs 3 and 4 in terms of gender distribution.



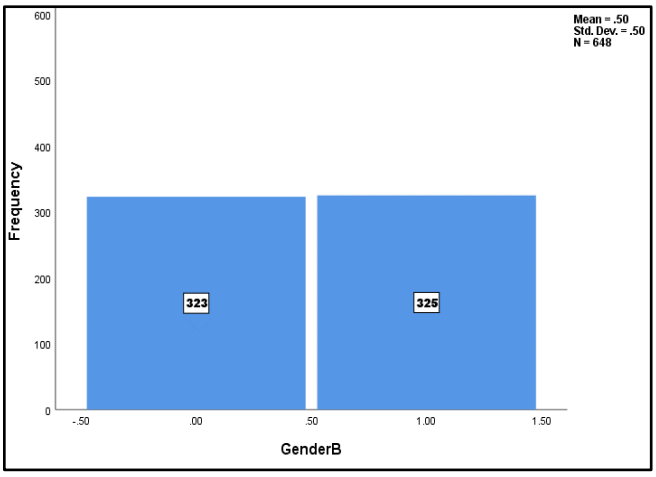


Fig. 3: Gender distribution

Lingala version (0=F) and (1=M) ***Kiswahili version (0=F) and (1=M)***

Research question 1 (RQ1): Are there correlations between the age dependency norm values of auditory skills for the LEAQ Lingala and Kiswahili versions and the original German version?

In order to determine whether there is an association between age of children and the scores, a scatterplot and correlation analysis is used. The correlation is positive, and the scatterplot shows this positive relationship as the dependent variable score moves in a positive direction when age increases (figs 5 and 6). The correlation between age and total scores was calculated for both the Lingala and Kiswahili versions. The correlation coefficient of r= 0.77 (p=< 0.001) for the Lingala version was found to be high and the correlation coefficient of r = 0.81 (p=< 0.001) for the Kiswahili version was also found to be very high.

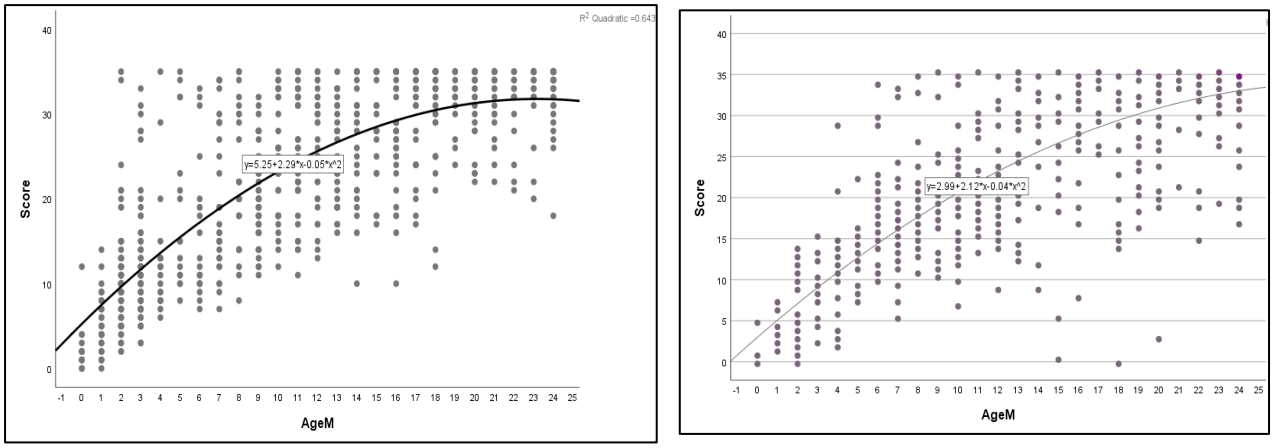


Fig. 4: Scatterplot: ***Lingala version (N=723)*** ***Kiswahili version (N=648)***

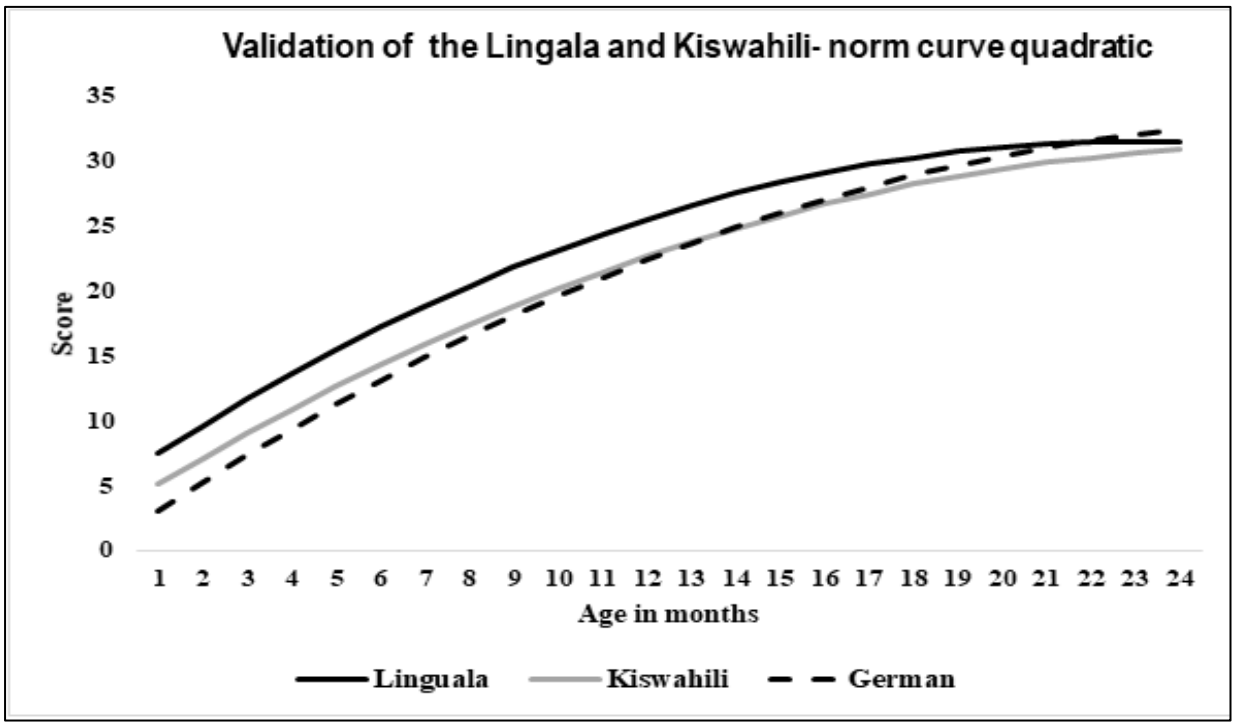


Fig. 5: LEAQ validation data for normal hearing children for the Lingala and the Kiswahili languages, compared to the German LEAQ (Coninx et al., 2009)

The regression curve with age as an independent variable and total scores as dependent variables shows that the responses for the Kiswahili version have been very similar to the German (the base version), and it is a little different but also very similar between the German and Lingala versions. This shows that the responses of the LEAQ scores are similar by age group, meaning that the process was probably very stable. Therefore, it can be assumed that even when the LEAQ is conducted in different multilanguage countries, the test is effective and shows similar results. This is likely to be because it is easy to administer and is also culturally adapted.

Table 2: Means, standard deviations and correlations with confidence intervals for the Lingala version

Variables	*M*	*SD*	*1*	*2*
1. Age	10.92	7.20	77**	
2. Scores	21.81	10.53	77**	*1*

Table 3: Means, standard deviations and correlations with confidence intervals for the Kiswahili version

Variables	*M*	*SD*	*1*	*2*
1. Age	12.72	7.25	81**	
2. Scores	22.20	10.46	81**	*1*

Table 4: Parameters of the scale analysis: summary of the correlation between age and total score, global results (Europe, China, Russia, USA and Africa) (Adapted from Coninx et al., 2009)

Country (language)	**Sample size (*n*)**	**Corr. age + total score[a]**
Belgium (Flemish)	142	0.93
Bulgaria (Bulgarian)	101	0.82
China (Mandarin)	157	0.84
Finland (Finnish)	364	0.91
France (French)	216	0.83
Germany/Austria (German)	218	0.91
Greece (Greek)	93	0.80
Poland (Polish)	325	0.90
Romania (Romanian)	88	0.80
Russia (Russian)	180	0.93
Serbia (Serbian)	183	0.86
Slovakia (Slovak)	592	0.92
Slovenia (Slovenian)	366	0.92
Switzerland (German)	92	0.92
USA (English)	144	0.85
USA (Spanish)	48	0.93
Overall	**3309**	**0.89**
DRC/**Africa** (Lingala)	723	0.77
DRC/**Africa** (Kiswahili)	648	0.81

[a] ***Pearson's correlation coefficient ranges from 0 to 1, where a value of 0.7 or higher shows a high correlation.***

Research Question 2 (RQ2): Is there a difference between the auditory behaviour observed by respondents in urban (town) and in rural areas (village)?

Based on the assumption that "*respondents from towns or cities have less time with their children because of work, and children have more time with other caregivers compared to those from villages as in Africa"*, women from villages carry their children on their backs all the time. Meaning that, they should have better scores because they have more time to understand the auditory behaviour of their children compared to their peers in towns and cities.

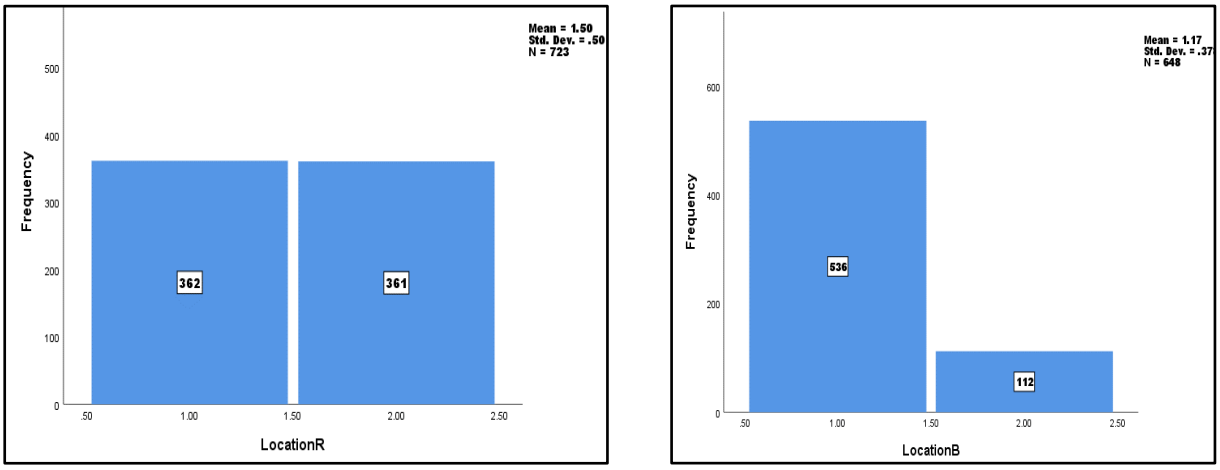


Fig. 6: Location for the Lingala and the Kiswahili respondents (1=town and 2=village)

In order to get the correlation between the respondents and the scores, descriptive statistics were used. The respondents were categorized for both Lingala and Kiswahili speakers as 1=town/city and 2=village (figs 8 and 9). The correlation between location (town and village) and total auditory scores was calculated for the Lingala speakers. With the correlation coefficient of r = -.05 (p= 0.149), the Lingala version was found to be not statistically significant and therefore *no* relationship exists between the location of respondents and the scores. This means that the location of the respondents either in a town/city or in a rural

area/village, including their lifestyles, does not have much influence on mothers' and caregivers' understanding of the auditory behaviours of their children.

Similarly, the correlation between location (town and village) and total auditory scores was calculated for Kiswahili, and the correlation coefficient of r = 0.07 (p= 0.053) was also found to be not statistically significant, and *no* relationship exists between the location of respondents and the LEAQ scores in Kiswahili speakers. As is seen in fig. 9, the distribution of people between locations is highly skewed. It does, however, meet the requirements of the central limit theorem with an N>30, meaning that the assumption of normality in parametric tests is fulfilled.

Research question 3 (RQ3): is there a difference between the auditory behaviour observed by respondents who are mothers (biological) and others (father, siblings, grandmother and caregivers)

Research question 3 is based on the assumption that *'Auditory behaviours observed by biological mothers are more accurate than behaviours observed by other caregivers (fathers, siblings, grandmothers)'.*

The rational for this research question is built on the fact that more than 60% of the data were collected from the respondents who were biological mothers found in paediatric services, and about 40% of the data were collected from health centres during routine immunization activities, whereby not only biological mothers bring children, but also other family members who may not know much about the child's auditory behaviours.

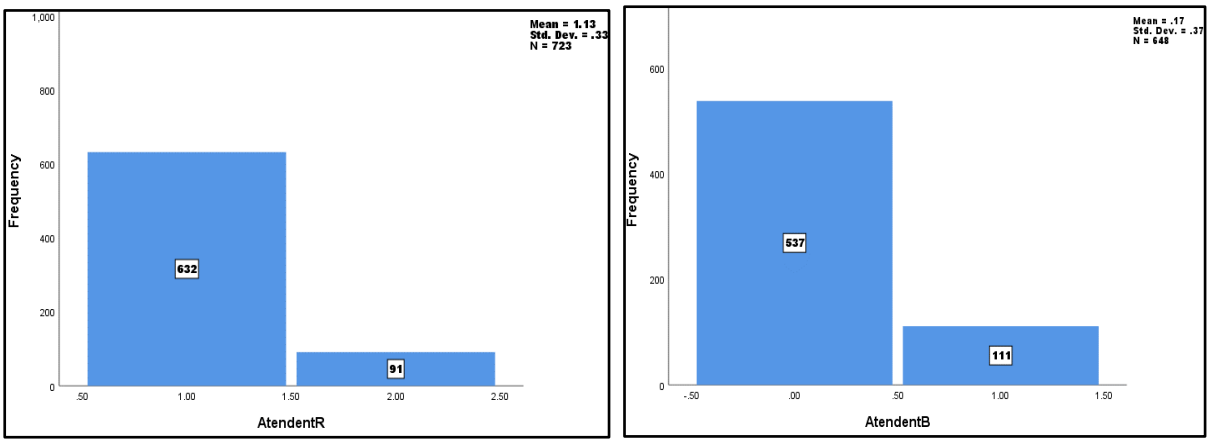


Fig. 7: Categories of attendants by language, who responded to the LEAQ
Lingala version (1=mothers and 2= others), Kiswahili (0=mothers and 1=others).

Descriptive statistics were used to get the correlation between the responses and the LEAQ scores from categories of attendants. The total number of biological mothers for the Lingala speakers were (N=632) and (N=91) for other caregivers composed of fathers, siblings and grandmothers.

The correlation between categories of attendants and total auditory scores was calculated for the Lingala version. With the correlation coefficient of r=0.00, (p=0.815) for Lingala speakers, this was found to be not statistically significant. Therefore, *no* relationship exists between categories of respondents and the LEAQ scores.

Correspondingly, in the attendants from the Kiswahili speakers, the total number of biological mothers was 537 and the total for other caregivers, composed of fathers, siblings and grandmothers, was 114. The correlation between categories of attendants and total LEAQ scores was calculated for the Kiswahili version. With the correlation coefficient of r=0.02 (p=0.526) for the Kiswahili version, this was found to be not statistically significant. Therefore, *no* relationship exists between categories of respondents and the scores. This means that the status of the respondents of being either biological mother or other, father, siblings,

grandmother, maid etc., has less effect on the LEAQ scores for both the Lingala and Kiswahili versions.

Research Question 4 (RQ4): Are the responses of mothers and caregivers dependent on the educational level?

The assumption for this research question is built on the fact that "*the education level of the respondents has a great impact on the understanding of the questionnaire as well as on the LEAQ scores*".

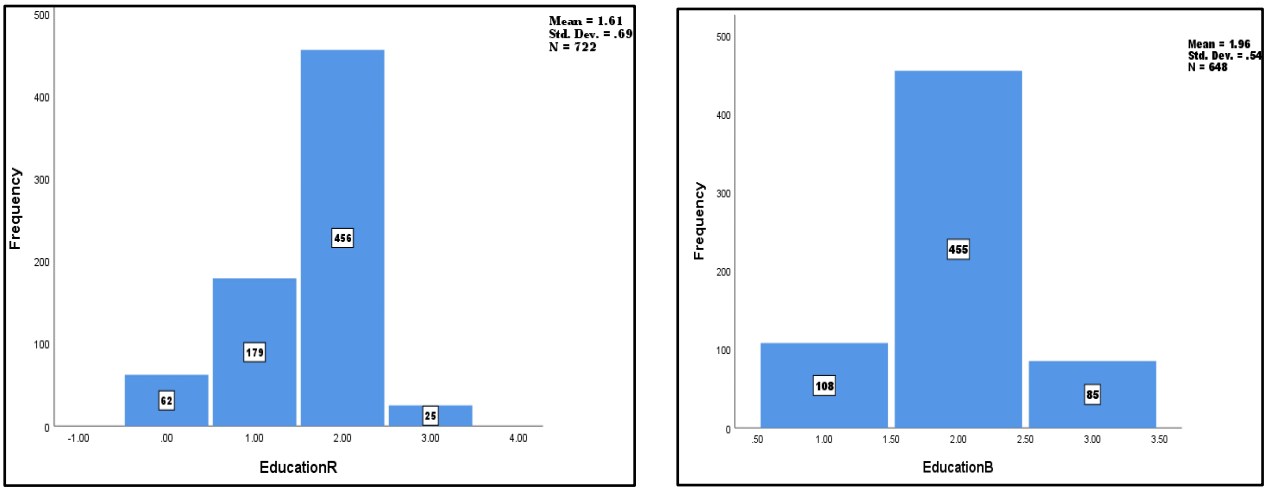


Fig. 8: Distribution of respondents by level of education (12. Lingala and 13. Kiswahili)

(0=without education, 1=primary level, 2=secondary level and 3=university level)

In this study, the education level of the respondents was investigated. The results show that out of N=723 respondents for the Lingala version, 62 (8.6%) of the respondents had no education level, meaning they have never been to school; 179 (24.8%) had primary level education; 456 (63%) had secondary level education; 25 (3.5%) had attained university or tertiary level education; and 1 (0.1%) was missing value. It is observed that for the Lingala version, the number of respondents (25) who attained university level is not higher than the N=30 as is

required for the assumption of normality, according to the central limit theorem and should therefore be carefully interpreted.

In order to compare the impact or the effects of education level on the LEAQ scores, a one-way ANOVA was used, and the test did not reveal a significant difference in the LEAQ Scores and the education level of respondents p= 0.971.

Table 5: Mean and total number of respondents by level of education for the Lingala version

Dependent Variables	*N*	*M*
1. Secondary (S)	*456*	21.65
2. Primary (P)	*179*	21.92
3. Others (with no education) (O)	*62*	22.45
4. University (U)	*25*	22.48

The scatter plot and the Mean Plot of age in months with LEAQ score by education of attendants were considered to determine differences between categories by education groups. Without any statistical significance for the Lingala version, respondents who have primary (M=21.65) and secondary (M=21.92) education levels, seem to be relatively closer to each other and had better LEAQ scores, compared to those without any education level (M=22.45) and those with university level education (M=22.48). This could also be explained by the presence of outliers as observed in the scatterplot, which may originate from the fact that the respondents with no education level had more help, and it is possible that they could have expressed some uncertain answers compared to those who were not aided. In addition, the difference of the means observed between the respondents of group one (primary and

secondary level) and group 2 (those without education and with university level), can also be explained by the large disproportion of the numbers.

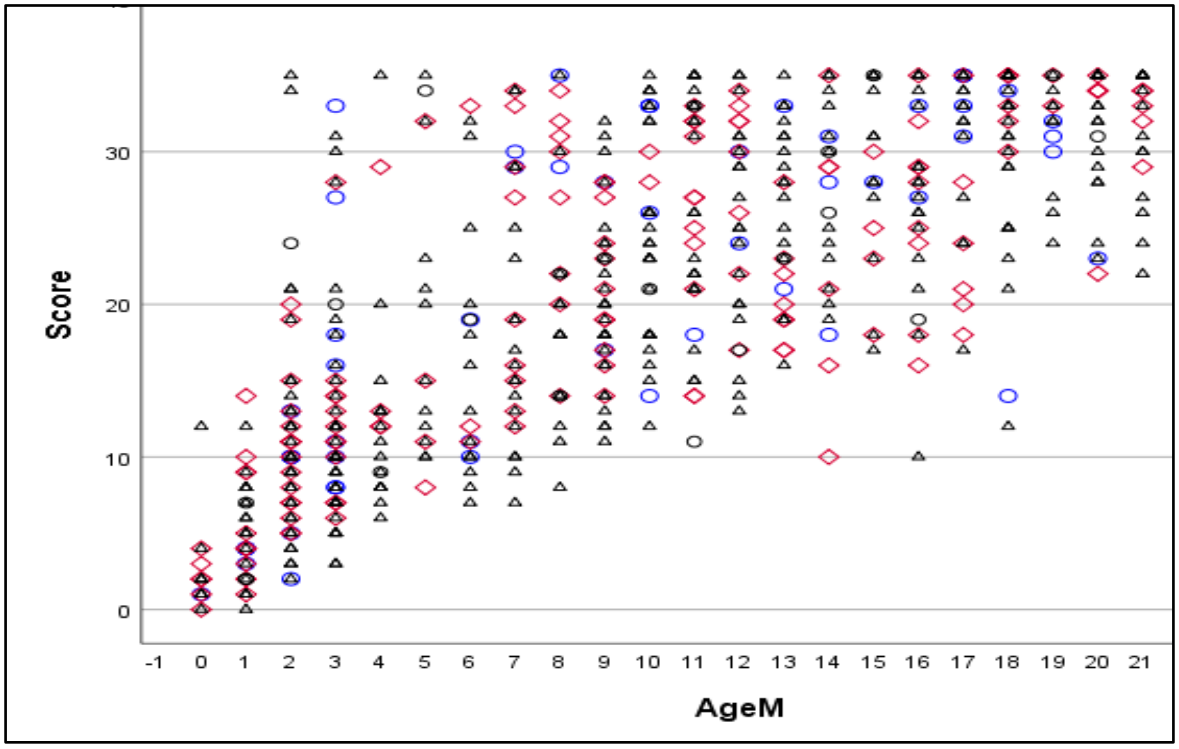


Fig. *9*: Scatterplot of age in months with LEAQ score by education of attendants (Lingala version)

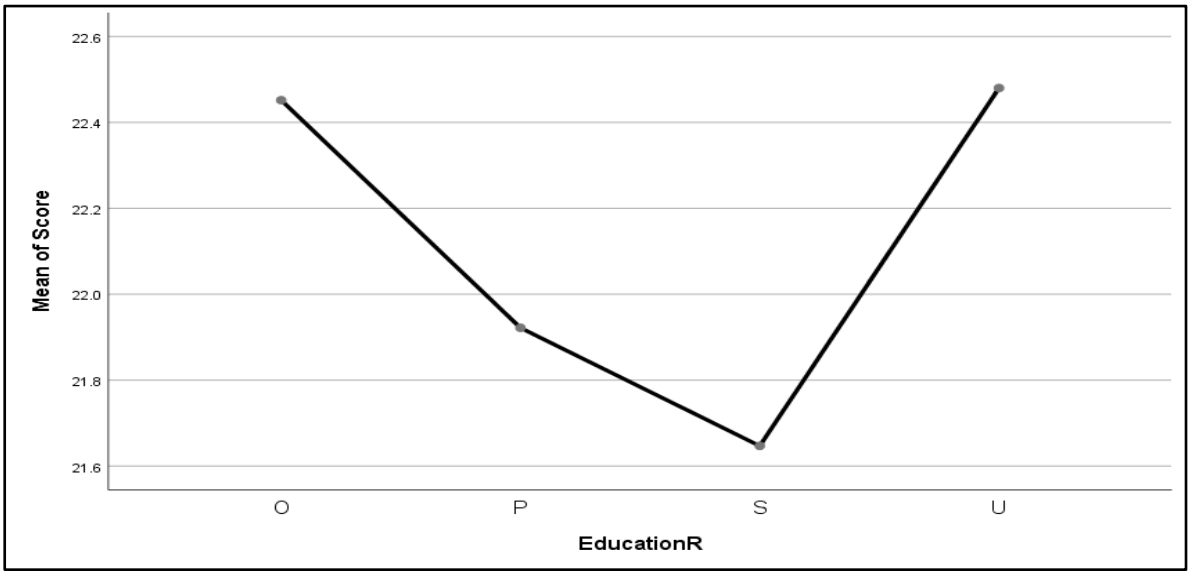


Fig. 10: Means plots of age in months with LEAQ score by education of attendants (Lingala version)

Similarly, for the Kiswahili version, the results show that out of 648 respondents, 108 (16.7%) of the respondents had primary level education, 455 (70.2%) had secondary level education and 85 (13.1%) had attained university or tertiary level of education. There was no record for respondents without education in the Kiswahili speakers (see fig. 12).

In order to compare the impact or the effects of education level on the LEAQ scores, a one-way ANOVA was used. The test did not reveal a significant difference in the LEAQ scores, and the education level of respondents was p=0.126 for Kiswahili speakers.

Table 6: Mean and total number of respondents by level of education for the Kiswahili version

Dependent variables	***N***	***Mean***
U=university	85	20.61
S=secondary	455	22.27
P=primary	108	23.15

To determine the differences between categories by education groups and the LEAQ scores, the scatterplot and the mean plot of age in months with LEAQ score by education level of the attendants was considered for the Kiswahili version as well. Although not statistically significant, respondents who have university level education (mean= 0.61) seem to have better LEAQ scores compared to those with secondary level (mean=22.27) and primary (mean=23.15). The lack of respondents without education level in the Kiswahili-speaking province could be due to the high rate of education (INS, 2017), compared to the Lingala-speaking provinces.

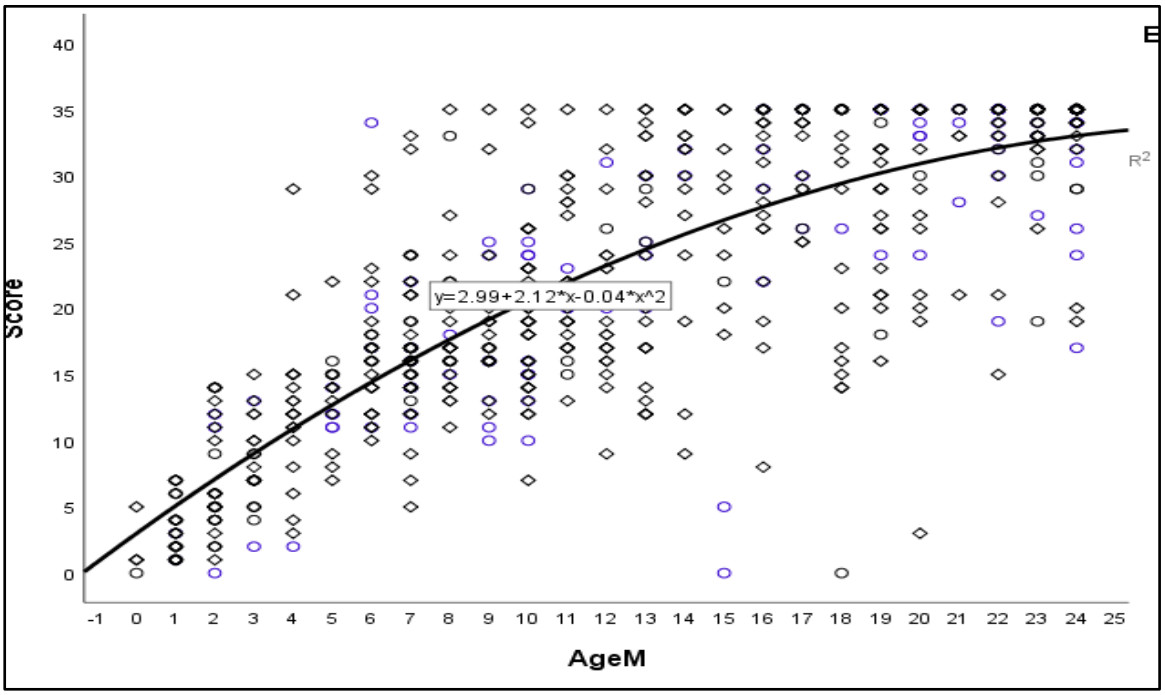


Fig. 11: Scatterplot of age in months with LEAQ score by education of attendants (Kiswahili version)

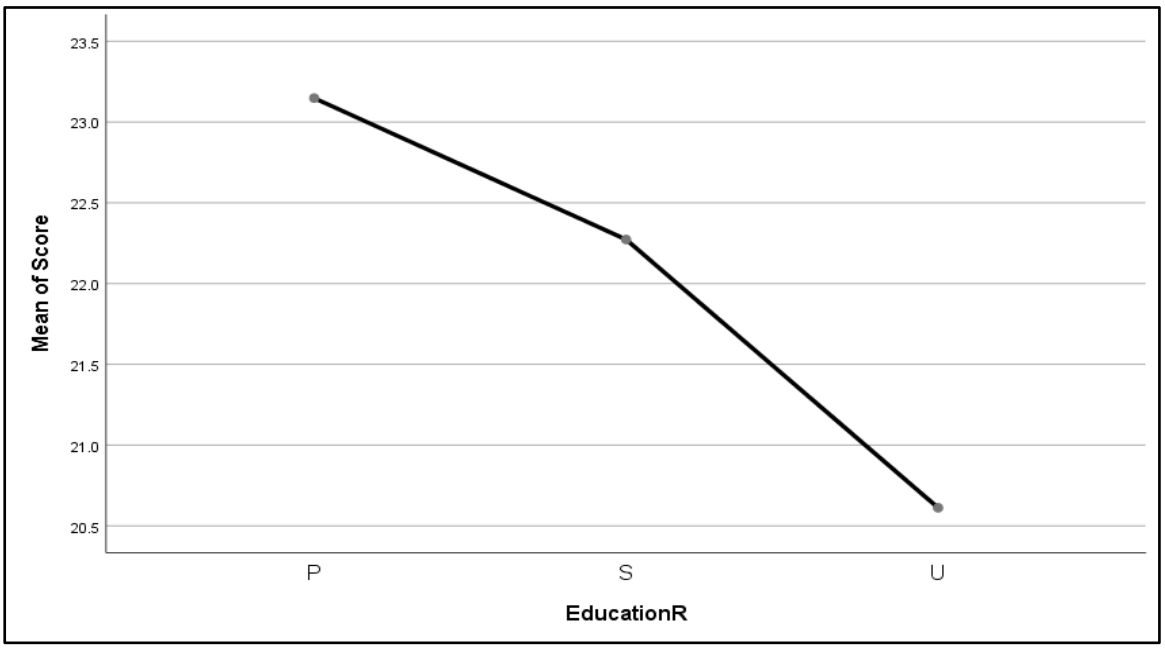


Fig. 12: Means plots of age in months with LEAQ score by education of attendants (Kiswahili version)

Research question 5 (RQ5): How appropriate is the LEAQ as a community-based screening tool in detecting auditory deficiency in children aged 0–24 months in a multilingual country?

Out of 723 children screened with LEAQ for the Lingala version, 168 (23.2%) of children whose LEAQ scores were below the expected values, were rescheduled at the ENT and Audiology hospital for otoscopy and tympanometry tests, out of which, 63 (37.5%) attended. From the 63 children who attended the ENT and Audiology hospital, a total of 28 (44.4%) were 'true positive' and 35 (55.6%) were 'false positive'. Out of 28 true positives 4 (6.3%) were found with impacted wax bilaterally, 19 (30.1%) were found with OME, 1 (1.6%) whose scores were 0 at the age of 10 months had cerebral palsy (CP), and 4 (6.3%) had pus in the ears unilaterally. The bar charts below (figs. 13, 14 and 15) give more detail.

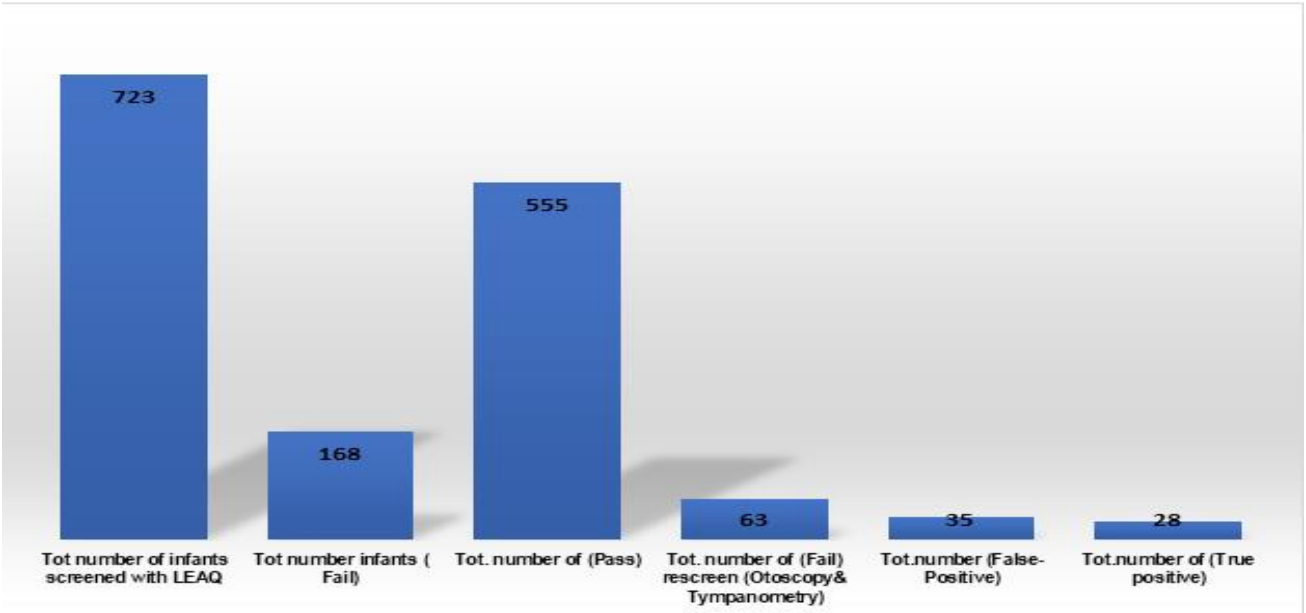


Fig. 13: Results of the follow-up test with tympanometry of 168 infants after failed LEAQ screening for the Lingala version

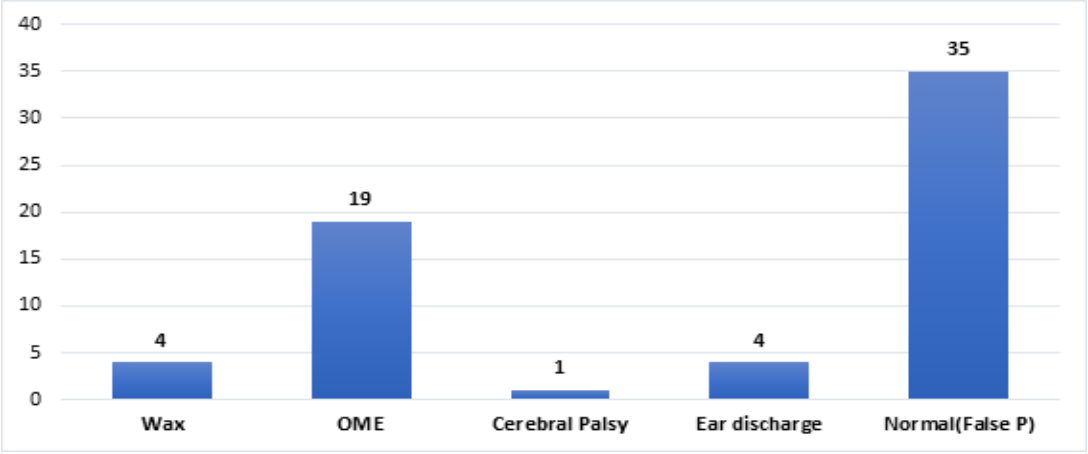


Fig. 14: Results of tympanometry of N=63 with LEAQ scores below the expected values

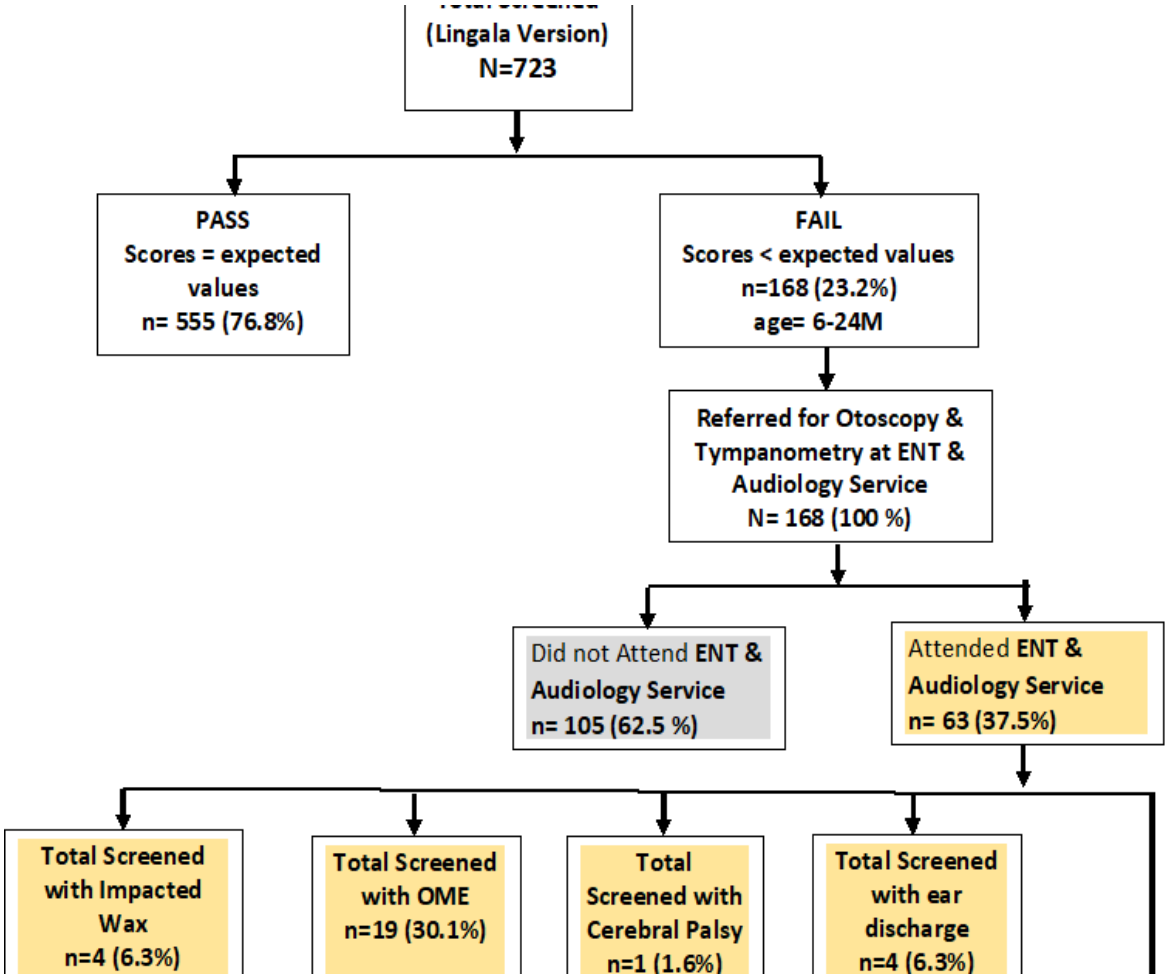


Fig. 15 Results of the follow-up test with otoscopy and tympanometry at the ENT and Audiology Service of children from the Lingala speakers

The results shown in fig.15 show the outcome of the first screening using the LEAQ and the follow-up of children who were considered ‘Fail’. The criteria for ‘Fail’ was based on the expected values of the LEAQ scores by age from the German version, considered as the original version of the LEAQ (Coninx et al., 2009). Due to the limited time, only children with the LEAQ scores below the expected values and aged 6 to 24 months were considered for a follow-up at the ENT and Audiology Hospital. In addition, due to the outbreak of coronavirus (COVID-19) from March 2020, the second follow-up after the first screening with the LEAQ was not possible in the Kiswahili-speaking provinces due to the lockdown and the ban on transport.

Besides the lack of total attendance of the referred children and looking at the results (fig. 15) and the total children who had a “pass” (n=555) after the screening with the LEAQ and those who attended the ENT and Audiology hospital for otoscopy and tympanometry (n=63), make a total of N=618 of children who can be considered screened and had a follow-up for the second screening at the hospital. By leaving out 105 children who failed the LEAQ and did not attend the second screening, and considering from the graph, the 28 children out of 618 who were screened as having a hearing disorder, it is possible to estimate that the prevalence of children at risk of having hearing loss in this population aged from 0–24 months from the Lingala speakers is 4.5%.

Research question 6 (RQ6): How appropriate and sensitive is the LEAQ as a community-based screening tool in detecting auditory deficiency in children aged 25–36 months?

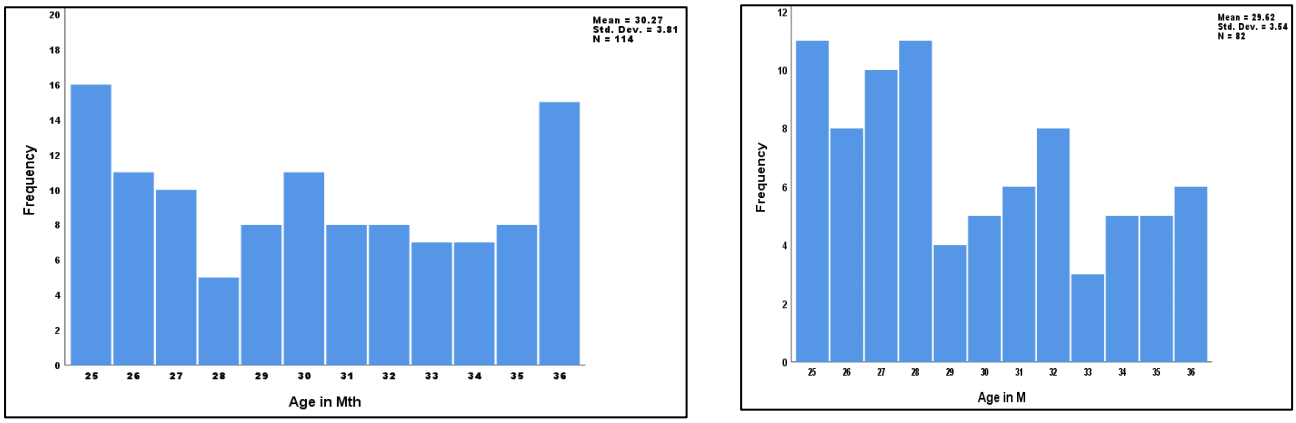


Fig. 16: Age distribution in months: *Lingala N=114, Kiswahili N=82*

The histogram (fig. 16) shows that the age distribution for children aged 25–36 months is even for the Lingala version, but a bit skewed for Kiswahili. Both the Lingala and Kiswahili versions have a similar mean (mean = 30.27) and (mean = 29.62) respectively, with a low standard deviation (SD=3.81) for Lingala and (SD=3.54) for the Kiswahili version, which indicates that the values tend to be close to the mean.

The scatterplot and a correlation analysis were used for this age group (25–36 months) in order to determine whether there is an association between age and the scores. The scatterplot shows a positive relationship as the dependent variable score reaches the maximum of 35. In this case, despite the correlation between age and total scores for both the Lingala and the Kiswahili versions, the relationship is not statistically significant at p=0.077 for the Lingala version and p=0.226 for the Kiswahili version. The LEAQ remains sensitive to detect children at risk of hearing loss at this third year of age, especially in an African context where many children in

rural areas are confronted with malnutrition and other developmental aspects. This is the case with the Kiswahili version (fig. 17), whereby the LEAQ identified a child of 26 months with bilateral atresia and microtia who scored 0, and a child of 30 months with severe malnutrition who scored only 16.

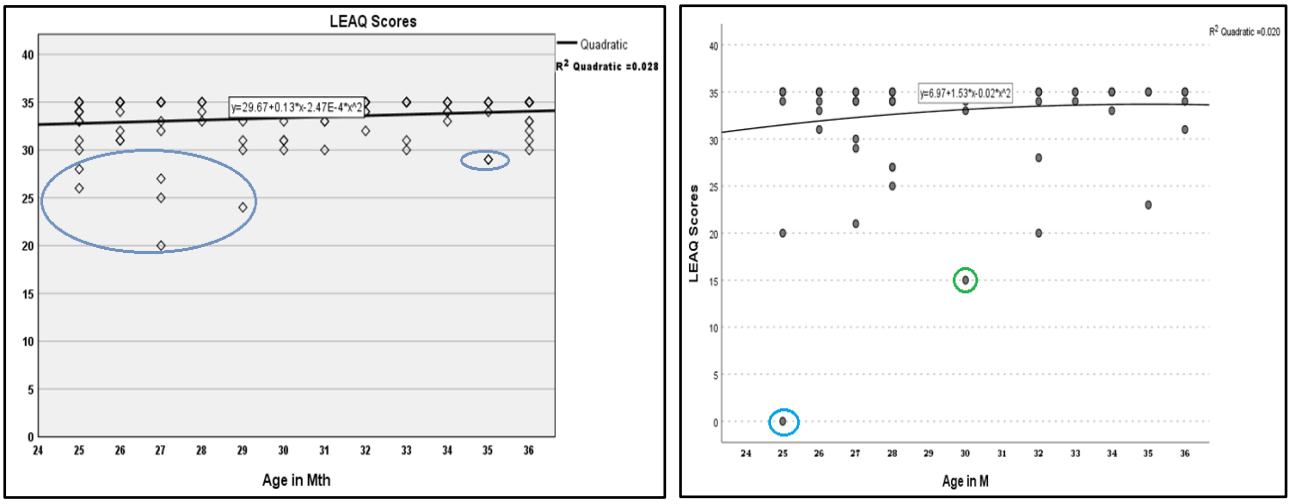


Fig. 17: The scatterplot for the Lingala and Kiswahili versions

Table 7: Means, standard deviations and correlations with confidence intervals for the Lingala version for ages 25–36 months (N=114)

Variables	*M*	*SD*	*1*	*2*
1. Age	*30.27*	3.81	.077	
2. LEAQ Scores	*33.39*	2.64	.077	*1*

Table 8: Means, standard deviations and correlations with confidence intervals for the Kiswahili version for the ages 25–36 months (N=82)

Variables	*M*	*SD*	*1*	*2*
1. Age	*29.62*	3.54	.226	
2. LEAQ scores	*32.78*	5.45	.226	*1*

Table 9: Multiple comparisons and mean differences by LEAQ score and education level for the Lingala version

(I) Education	(J) Education	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
=without ed	P=primary	.53	1.55	.98	-3.48	**4.54**
	S=secondary	.80	1.42	.94	-2.87	**4.48**
	U=university	-.02	2.50	1.00	-6.47	**6.41**
P=primary	O=without ed.	-.53	1.55	.98	-4.54	**3.48**
	S=secondary	.27	.93	.99	-2.12	**2.67**
	U=university	-.55	2.25	.99	-6.36	**5.25**
S=secondary	O=without ed.	-.80	1.42	.94	-4.48	**2.87**
	P=primary	-.27	.93	.99	-2.67	**2.12**
	U=university	-.83	2.16	.98	-6.42	**4.75**
U=university	O=without ed.	.02	2.50	1.00	-6.41	**6.47**
	P=primary	.55	2.25	.99	-5.25	**6.36**
	S=secondary	.83	2.16	.98	-4.75	**6.42**

Table 10: Multiple comparisons and mean differences by LEAQ score and education level for the Kiswahili version

(I) Education	(J) Education	Mean difference (I-J)	Std. Error	Sig.	95% Confidence interval	
					Lower Bound	*Upper Bound*
P=primary	S=secondary	.87	1.12	.71	-1.75	3.51
	U=university	2.53	1.51	.21	-1.03	6.10
S=secondar	P=primary	-.87	1.12	.71	-3.51	1.75
y	U=university	1.66	1.23	.37	-1.24	4.56
U=universit	P=primary	-2.53	1.51	.21	-6.10	1.03
y	S=secondary	-1.66	1.23	.37	-4.56	1.24

2.11 Discussion

RQ1

The goal of this study was to adapt and evaluate the sensitivity of the Lingala and Kiswahili versions of the LEAQ as a screening tool for hearing loss in children aged 0–24 months in the DRC. The version of the LEAQ translated to Lingala and Kiswahili was the result of the application of translation and back translation design for adaptation together with a systematic evaluation using qualitative methods.

This study indicates that from the data collected, N=723 babies from the Lingala version and N=648 babies from the Kiswahili version, the correlation between age and the LEAQ score mean differences was not significantly different from both the Lingala and Kiswahili versions, although the Lingala norm curve was slightly lower than the German norm curve, but they were all comparable. The slight difference in norm curve was also reported by Offei (2013) in Akwapen language in Ghana. The high correlation between the age and total score in Lingala and Kiswahili is consistent with other studies, especially with German (Coninx et al., 2009) as the original version, as well as in line with other languages, such as Fante, Akwapen and Asante in Ghana, Africa (Offei & Coninx, 2014), Polish (Obrycka et al., 2009), Mandarin (Wang et al., 2013), English (Canada) (Bagatto et al., 2011), Hebrew and Arabic (Geal-Dor et al., 2011), Spanish (Spitzer & Zavala, 2011; Negro, García, & Quevedo, 2016), Yoruba (Kayode & Adeyemo, 2018), Finnish (Rauhamäki et al., 2014), Swedish (Persson et al., 2019), Persian (Zarifiana et al., 2019).

This similarity shows that the adapted Lingala and Kiswahili versions of the LEAQ is appropriate for assessing auditory development in children below 24 months in the DRC.

Moreover, the strong correlation found between total scores and age supports the use of the LEAQ® version adapted to the Lingala and Kiswahili languages spoken in the DRC to monitor early auditory behaviour, make informed decisions in time and make valid inferences on the level of hearing development in children under 24 months.

RQ2

This study showed that the location of the respondents, N=723 from Lingala-speaking locations whereby about 50% of respondents were parents / caregivers living in the city, and N=648 Kiswahili-speaking respondents , whereby 83% were from rural areas/villages, regardless of their lifestyles, attention of mother to child and the time often granted to the child, has no influence on respondents' understanding of their children's hearing behaviour.

Women in the villages always carry their children on their backs (Riand, Plard & Moro, 2008). This means they should have better LEAQ scores because they have more time to understand their children's hearing behaviour compared to their peers in the cities.

This interesting aspect from an African perspective shows that the LEAQ is stable and language specific (Coninx et al., 2009), is adapted to the environment and has a cross-cultural characteristic. This means that the power of daily life, which is dictated by the life conditions in cities compared to those in villages, does not affect mothers' attention to their children's hearing behaviour. This characteristic is shown by the statistically insignificant correlation following the scores of the respondents, both by parents / guardians and by health professionals, in our study from their locations in towns and rural areas. In addition, this is also in line with the study by Ofei & Coninx (2014) that using a questionnaire as a screening tool enables screening services to be provided to several people in a variety of informal settings, which can be either characterized or defined by the location of the respondents.

Moreover, looking at the geographical accessibility, the dispersal of the population, the distance to be travelled to access the health centres (i.e., beyond 5 km or more than an hour's walk) and natural obstacles, especially rural areas, limit access to health services. Therefore, the LEAQ as a cross-culturally adapted, language-specific tool is a suitable screening tool that can contribute to improve community accessibility to ear and hearing health services, whereby in rural areas in the DRC, the distance to reach a health service is a problem for about 48% of women versus 25% in urban areas.

RQ3

In this study, the total number of biological mothers for Lingala speakers was (N=632), representing 88%. Similarly, respondents for the Kiswahili speakers, biological mothers were N=537, representing 83%. For both languages, the correlation coefficient was not statistically significant. Therefore, the study shows that no relationship exists between the categories of respondents and the LEAQ scores. This means that the status of the interviewee as a biological mother or other caregiver: father, siblings, grandmother, maid, etc. has less effect on LEAQ scores for the Lingala and Kiswahili versions.

This result is inconsistent with the studies conducted in 3 local languages in Ghana (Offei & Coninx, 2014) which showed that parents, particularly mothers, are with their children longer on a daily basis, and they are normally the first to detect the presence of a disability in their children. This state of being next to and more attached to their child, is at the heart of early parent-child interactions, in the dynamics of bonding and in emotional exchanges.

That is to say, the use of the LEAQ by biological parents would be preferable as it can have a positive implication on the conciseness for better orientation of the auditory behaviour of the child, although this research did not show a significant relationship between the scores of biological parents and other members. Another important aspect of involving more biological

mothers is to help them get more accurate knowledge of the process of the auditory behaviour assessment, and its benefit will impact not only the child in hand, but also future children. The more biological parents are involved and knowledgeable about LEAQ, the easier it will be to determine the perspectives towards the UNHS for appropriate advocacy interventions, as well as advocacy for the integration of the LEAQ into the primary health care package.

RQ4:

The effect of educational level on the LEAQ scores was compared for the Lingala and Kiswahili speakers in the DRC. The results show that there was no significant effect of respondents' educational level on the LEAQ scores.

This implies that the educational level of the respondents does not influence the results or scores of the LEAQ. This is in line with studies conducted in Ghana by Offei & Coninx (2014). Moreover, it also confirms that the LEAQ is valid and reliable (Coninx et al., 2009) as it cannot be affected by other factors, such as the level of education. Therefore, this finding has a large community implication for the country's future programme for the prevention of hearing loss and deafness, as the LEAQ can be considered a reliable screening tool for early identification in low-income countries, such as the DRC where hearing loss is prevalent. Similarly, as the UNHS programme is not yet implemented in the country and the LEAQ is a valid and reliable tool with acceptable criteria (Bogatto et al., 2011) for hearing screening, it is possible that the LEAQ can be used as an alternative means of early detection of hearing loss in the DRC.

RQ5

The findings of this study show that the LEAQ is sensitive and is an appropriate tool in detecting not only children with auditory deficiency aged 0–24 months, but also other developmental anomalies (Schaefer, Coninx & Fischbach, 2019). Out of 28 children who were

screened having a hearing disorder, in the Lingala-speaking respondents, 19 children were found with OME, 4 children were found with impacted wax bilaterally, 4 other children had pus in the ears unilaterally and 1 child whose score was 0 at the age of 10 months was a child with CP.

This study agrees with the one previously carried out in Germany by Schaefer, Coninx & Fischbach, (2019), of which the results indicated that 43.8% of infants who failed the LEAQ screening had other developmental abnormalities on the follow-up examination, which had not been previously identified. Furthermore, this finding is consistent with Coninx et al., (2009) who established that the LEAQ was not only accurate, gender independent and age dependent, but it was also a language-independent tool.

The aspect of other children with developmental problems that Schaefer, Coninx & Fischbach (2019) reported in their study, is related to the fact that in this study, one child whose score was 0 at the age of 10 months was a child with CP. This shows that in a context where the screening of children with disabilities in general is still not a priority at an early age of life, and many families in Africa often have a tendency to hide or not even talk about disability because it is considered a taboo or a curse, the same case as mentioned by Offei (2013) in his research in Ghana, with the LEAQ, it is possible to reach the respondents in their ordinary environment where the answers are given freely depending on mothers' experiences and direct observations of their child's behaviour.

The identification of a child with CP has significant community implications in the sense that community awareness oriented towards mothers and other caregivers about the LEAQ is crucial for early identification of auditory-related behavioural disorders that can be associated with other conditions, either congenital or acquired. This finding highlights again the need for follow-up after first screening (Coninx et al., 2009)

Besides this, the study shows that in the 19 children (2.6%) of the total number of children who participated in this study, whose mothers and caregivers were Lingala speakers, after otoscopy and tympanometry, they were found to be suffering from otitis media with effusion (OME). This result is in accordance with Schaefer, Coninx & Fischbach, (2019), who found infants with a mean age of 12 months who had recurrent otitis media within their first year of life failed the screening using the LEAQ indicating that this screening procedure may also be effective in identifying infants with mild HL (30–40 dB). In fact, language development is generally assumed to have its sensitive period during early childhood, particularly during the first 2 years of life when basic language skills are acquired, forming the basis for further language development. Therefore, any reduction in the quality of language input during this period could result in a setback that may never be compensated (Zumach et al., 2010).

Although most cases of OME resolve on their own, it can persist in some children causing hearing loss. This condition is often underdiagnosed, leading to an untreated hearing problem, which can result in delayed speech and language development in a country like the DRC where the ENT and audiology services are rare. With this condition, the LEAQ has a crucial implication in the early detection of children with OME (Gan et al., 2018).

RQ6

The results of the study show that from the respondents in the Kiswahili-speaking group, 2 children (2.4%) out of N=82 failed the LEAQ. The first child, aged 26 months, scored 0 and was diagnosed with bilateral atresia and microtia, and the second child of 30 months scored 16 and was diagnosed with severe malnutrition. Following this, results indicate that the LEAQ remains sensitive to detect children at risk of hearing loss at this third year of age, especially in an African context where many children in rural areas are confronted with malnutrition and other developmental aspects. This is in accordance with Offei (2013) that the LEAQ can be

used as a screening tool in infants aged up to 3 years old, especially in regions where there is no UNHS programme, and the DR Congo is one of them. The adaptation of the LEAQ in 2 languages, Lingala and Kiswahili, constitute a first step in the early detection of children with hearing disorders, and the use of concrete data of the LEAQ will have considerable impact in influencing the legislation and the integration of the LEAQ as a valid tool in the primary health care package.

2.12 Summary and conclusion

2.12.1 Summary

The goal of this study was to adapt and evaluate the sensitivity of the Lingala and Kiswahili versions of the LEAQ as a screening tool for hearing loss in children aged 0–24 months in the DRC. The version of the LEAQ translated to Lingala and Kiswahili was the result of the application of translation and back translation design for the adaptation, together with a systematic evaluation using qualitative methods. This study shows that, the adapted Lingala and Kiswahili version of the LEAQ, is appropriate for assessing auditory development in children below 24 months in the DRC.

In the DRC, there are many challenges related the geographical accessibility, the dispersal of the population, the distance to be travelled to access the health centres, and natural obstacles, especially in rural areas, limit access to health services. Therefore, the LEAQ as a cross-cultural adapted, language-specific tool is a suitable screening tool that can contribute to improve the community accessibility on ear and hearing health services, whereby in rural areas in the DRC, the distance to reach a health service is a problem for about 48% of women versus 25% in urban areas.

Although this research did not show a significant relationship between the scores by biological parents and other members, the study suggests that the use of LEAQ by biological parents would be preferable as it can have positive implications on their conciseness for better orientation of the auditory behaviour of the child. This is because the state of being next to and more attached to her child, is at the heart of early parent-child interactions, in the dynamics of bonding and emotional exchanges.

Another important aspect of involving more biological mothers is to help them get more accurate knowledge of the process of the auditory behaviour assessment and its benefit will impact not only the child in hand, but also future children.

Similarly, there was no significant effect of respondents' educational level on the LEAQ scores. This means that the educational level of the respondents does not influence the results or scores of the LEAQ. This implies that the LEAQ is valid and reliable as it cannot be affected by other factors such as the level of education. This finding has a large community implication for the country's future programme and the LEAQ can be used as an alternative means of early detection of hearing loss in the DRC.

In a context where the screening of children with disabilities in general is still not a priority at an early age of life, and many families in Africa often have a tendency to hide or not even talk about disability because it is considered a taboo or a curse, the LEAQ was proved to be sensitive and was an appropriate tool in detecting not only children with auditory deficiency, but also other developmental anomalies.

The identification of a child with CP has significant community implications in the sense that community awareness oriented for the mothers and other caregivers about the LEAQ is crucial, for early identification of auditory-related behaviour disorders that can be associated with other conditions, either congenital or acquired. This finding highlights again the need for follow-up after first screening with the LEAQ.

Moreover, the lack of appropriate tools to minimize any reduction in the quality of language input during the first 2 years, such as that caused by OME, could result in a setback that may

never be compensated. This indicates that the screening procedure using the LEAQ may also be effective in identifying infants with mild HL (30–40 dB), especially in a country like the DRC where the ENT and audiology services are almost non-existent in rural areas.

Furthermore, in an African context where many children in rural areas are confronted with malnutrition and other developmental aspects, the LEAQ can be used as a screening tool in infants aged up to 3 years old, especially where there is no UNHS programme like in the DR Congo. This can have a positive implication by generating concrete data that will have considerable impact in influencing the legislation and the integration of the LEAQ as a screening tool in the primary health care package.

2.12.2 Conclusion

According to the WHO (2020c), screening is a brief and simple procedure used to identify infants and young children who may be at risk for potential health, developmental, or socio-emotional problems. Screening helps to identify children who may need a health, diagnostic or educational assessment. 'Screening' involves the use of a standardized instrument, such as parental questionnaire or observation that has been validated by research to learn more about the development of the child.

This chapter was aimed at the development of the first hearing screening tools for infants and children**.** The LEAQ, unlike most of the other tools that have been evaluated, is based on conceptual clarity, standards, measurement models and accessible language adaptation.

To date, the LEAQ has only been adapted in Ghana in 3 Akan languages, Fanti, Akwapen and Asante, which has made it impossible to benefit many other African language speakers like Lingala and Kiswahili speakers in the DRC, since it is one of the most linguistically diverse countries in the world. As such, the adaptation of the LEAQ into Lingala and Kiswahili would benefit over 36 million people in the DRC.

The adaptation of the LEAQ into 2 languages, Lingala and Kiswahili, constitutes a first step in the early detection of children with hearing disorders, and the use of concrete data of the LEAQ will have considerable impact in influencing the legislation and the integration of the LEAQ as a valid tool in the primary health care package.

CHAPTER THREE: THE ADAPTIVE AUDITORY SPEECH TEST (AAST)

3.1 The AAST and its global evolution

Historically, there are many tests developed and used to diagnose hearing loss. According to ASHA (2004), a proper diagnosis procedure involves a comprehensive audiological assessment that includes: otoscopy, tympanometry, acoustic reflex, pure-tone audiometry and speech audiometry (McArdle & Wilson, 2009). There are also physiological tests available to determine the status of the middle ear, like immittance testing, and also the status of the central auditory pathways: the auditory brainstem test and acoustic reflex testing (Katz, 2009). The results of these tests are important and relevant in the management of the person's hearing loss (Katz, 2009).

Similarly, speech audiometry in audiological settings is paramount for the rehabilitation of a child. Many of these speech tests have their origin in English, including AB Word Lists, Manchester Word Lists (Watson, 1967), the Ling Sounds (Ling, 1976; Romanik, 1990; Australian Hearing Manual of Speech Perception, (Ling, 1976; Romanik, 1990; Australian Hearing Manual of Speech Perception, 1999; Agung, Purdy, & Kitamura, 2005); Toy Tests – Kendall and McCormick (McCormick, 1977), Maltby Speech Perception Test (Maltby, 2000), Four Alternative Auditory Feature Test (FAAF) (John & Mark, (1987), Closed-Set Tests (Hirsh, 1948), The Word Intelligibility by Picture Identification (WIPI) (Cienkowski et al., 2009), The Northwestern University Children's Perception of Speech (NU-CHIPS) (Elliott & Katz, 1980), The Digit Triplets Test (Smits, at al., 2004), and the AAST by Coninx (2004; 2005).

Since many of these tests have been developed in English, the adapted versions of them have been developed by several countries in their national languages, such as France and Belgium (Luts et al., 2008; Jansen et al., 2010; Matray & Pirou 2012; Wable, 2001) and many others (Aleksandrovsky et al., 1998; Ozimek, et al., 2009; Gaeta John, 2015; Ramkissoon et al., 2002; King, 2010; Coninx et al., 2007). Some of these tests are also adapted into African languages, such as Zulu and Tswana in South Africa (Khoza et al., 2008; Shangase, & Mokoena, 2014; Panday et al., 2007). Similarly, there is an adapted version of French Canadian that has been developed because of linguistic differences between Canadian and European French (Vaillancourt et al., 2005; 2008; Vincent et al., 2017; Lebel & Picard, 1995*).*

Besides all these tests, the AAST has already been adapted in several languages: Deutsch (German), Chinese, Dutch and English. Furthermore, recent research by Offei (2013) demonstrated that the AAST had been adapted in 3 local languages in Ghana, in the Akan-Fanti, Akuapem and Asante languages, and it was shown to be a reliable tool for screening children, in both monolingual and multilingual societies.

In east and central Africa, many countries speak Swahili as a regional language (Palma, 2008). In the DRC situated in central Africa, there is no literature found about the adapted version of the AAST , despite it's all linguistic and multicultural richness as a country with 4 national languages: Lingala, Swahili, Tshiluba and Tsikongo. Given the adaptation of the tests from their original version to other national languages (an example is the adapted version of French spoken in France into French Canadian, from English version to Asante and Fante in Ghana (Offei,2013), there should also be a test version adapted to DRC languages, particularly the AAST version to Congolese French, and also in Kiswahili. Given this, the research identifies the possibility of constructing a comprehensive adapted package of tools, for audiological assessment in the DRC.

3.2 Why AAST?

The AAST test seems suitable for this study because of its procedure, which fulfills some important criteria for possible use as an instrument, not only for screening but also for diagnosis. These criteria include the automated process, its community-based character i.e. can be used by non-specifically trained personnel, since the test results are independent of the examiner's interpretation. Additionally, the test runs for approximately 2 minutes per ear and approximately four to five minutes total time for both ears with a standard deviation of less than 5 dB (Coninx 2005). AAST is a closed procedure (closed set) which, due to its reduced number of items, is not sensitive to factors which are not primarily audiogenic (vocabulary, pronunciation) (Hoffmann V., Schäfer K. & Coninx F. 2018) and is therefore particularly suitable for use in younger children from the age of three to four years. In most cases, the test is made up of six spondees from the child's vocabulary, but where the spondees are impractical or do not exist, the test can be made up of tri-syllable words (Coninx 2005). These words constituting the test are visually represented in the form of locally acceptable and easily recognizable pictures. During test execution, one of the six words is randomly offered by a speaker (which constitutes a stimulus) and can be identified by the subject or the testee by typing or by pointing to the visual model displayed on the screen or point to the visual model printed on cardboard (which constitutes the answer). After each correct answer, the next word is offered 5 dB lower, after a wrong answer then 10 dB higher. In this way, the method automatically adapts to the understanding threshold of the individual language. The pace of the test also adapts individually, and the test words are in random order to exclude learning effects. In the standard adaptive form, the procedure ends after 3 inflection points triggered by error (Coninx 2005). Therefore, these practical conditions constitute the fundamental reason for choosing this AAST test for this study in the DRCongo.

Besides French and Lingala, research has shown that about 40% of the Congolese population can express themselves in Kiswahili, which also makes it the most spoken language of the country, mainly in the eastern provinces: North and South Kivu, Maniema, Katanga and Ituri Province, formerly Orientale Province) (Palma, 2008; LECLERC 2014).

3.3 Geographical distribution of Kiswahili languages in the DRC

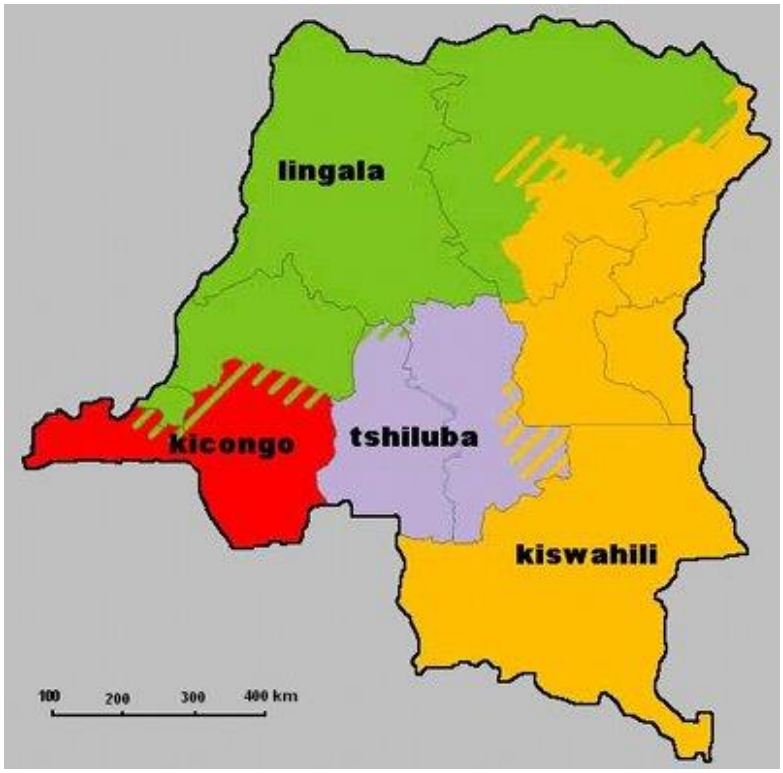


Fig. 18: The geographical distribution of the 4 national languages in the DRC (LECLERC, (2014)

The Adaptive Auditory Speech Test (AAST) has been developed to test the auditory perception of speech by young children under realistic conditions (Coninx, 2005). The focus of the test is to assess skills at the detection level as well as at the discrimination level. AAST has been adapted into many language versions in order to be usable as a screening tool for children.

Norm data is therefore required to provide a standard baseline against which the results obtained from the evaluation tool, both for normal hearing- and hearing-impaired children, can be compared. According to Bagatto et al. (2011), a good outcome evaluation tool should have conceptual clarity and normative data in order for meaningful comparisons to be made.

3.4. Objective and Research Question

3.4.1 Objective

The main objective of this chapter is to construct and validate the Kiswahili versions of the AAST for children aged 3-4 years and older.

3.4.2 Research question

The main research question for this study is as follows:

How can the AAST be adapted and used as an assessment and diagnostic tool to determine the speech reception threshold (SRT) in children and adults in the DR Congo.

Four sub-questions have been formulated to answer the main question for this chapter

- What are the behaviors before and during the AAST test that can positively or negatively influence the results of the test in children
- What is the age-dependent normative values for the AAST Kiswahili versions, in comparison to the German versions?
- Are children with thresholds 30-40 dB higher than normal having middle ear problems or other health condition ?
- What is the learning effect of the AAST test words in the Kiswahili language ?

3.5 Methodology

This part of the methodology is divided into two parts: the first focuses on <<***Criteria for test construction***>> These criteria follow the procedures according to the construction of the first test by Coninx (2005) the second part of the methodology will focus on **<<*Norms and reference values***>>** to validate the AAST Kiswahili version.

3.5.1 Criteria for test construction (Words selections & construction of AAST Kiswahili version)

Among other software tests, such as the Battery for Listening Evaluation and Language Skills (BELLS), the AAST (Coninx, 2005) has been adapted and used in various rehabilitation hearing institutions in Germany, Belgium, the Netherlands and France, as well as in one of the African countries, Ghana, to determine speech perception abilities in kindergarten and school-aged children, using CIs or hearing aids, and who acquired hearing loss during their first year of life. Most of these countries used the 6-spondee words version. For this study, a version of 6 trisyllabic words was adapted in Kiswahili spoken in the Democratic Republic of the Congo.

For word selection, a descriptive design (Kothari, 2004) was adopted aimed at giving an overview of the level of knowledge of children aged 3 to 4, young people aged 15 to 25 and people from 60 to 70 years old, about the meaning of selected pictures shown to them and that are locally known and commonly used. The preliminary criteria for selecting pictures for the AAST were based on the same criteria considered in several languages including:

• all pictures were in the same style

• pictures were locally drawn and had the following details: JPG format, 201x174 pixels

• color or black ink drawn on white card.

The choice of target participants was based on purposive sampling. Evidence shows that purposive sampling is where the researcher relies on experience and knowledge of the group to be sampled (Gay, Mills & Airasian, 2010; Orodho, 2012). For this study, the researcher targeted a specific age in specific areas with specific language.

3.5.2 Target population for the AAST words

Data were collected from N= 154 . Participants were assessed by age categories (3–4 years), (15–25 years) and (60–70 years).

3.5.3 Choice of words

The choice of words followed the AAST protocol procedures (Coninx, 2017). Due to the lack of spondee words Kiswahili, 10 trisyllable- words were selected in Kiswahili) based on pictures of objects or materials that are known or commonly used in the community. These 10 trisyllable words were represented in pictures on the cards, each picture on one card .

Despite the same criteria followed in the selection of speech material, with preference given to spondee words, the use of trisyllabic words in speech audiometry instead of spondees in languages where no spondees exist, has been evaluated more recently in Mandarin, with the result of a comparable function of growth emphasizing the use of trisyllables instead of spondees to assess the SRT value (Nekes, 2016).

For cultural purposes, pictures were drawn locally so they were friendly to children. A pilot test was conducted before collecting statistical data, where 30 children in total were involved: 15 from eastern south province: Katanga and from eastern Ituri Province. The aim of this pilot testing was to help the researcher to remove or keep at least 6 pictures that are more commonly accepted according to their high rate of recognition by participants. Pictures on the cards were presented one picture at a time for the children.

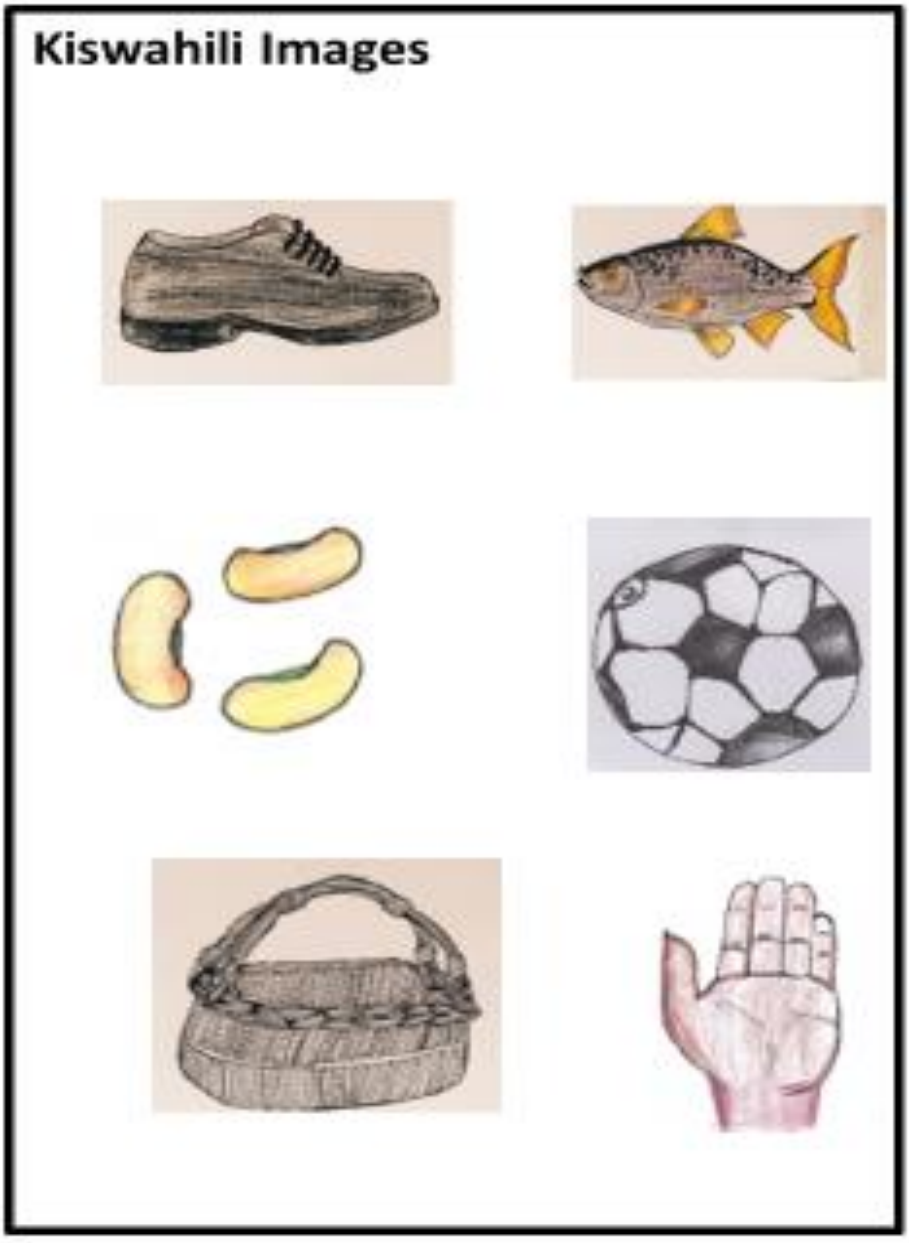


Fig. 19: Selected pictures in Kiswahili for the adaptation of the AAST

3.5.4 Sample Size

The sample size comprised 180 respondents in total, including: 90 participants from Ituri Province, 90 participants from Katanga Province.

Table 11: Estimated number of participants by geographical province

Geographical location	Provinces	City/Village	Participants			Total
				Kiswahili		
Eastern	Ituri	Bunia	Infant	30	-	30
			Young	30	-	30
			Adult	30	-	30
Southern	Katanga	Lubumbashi	Infant	30	-	30
			Young	30	-	30
			Adult	30	-	30
						180

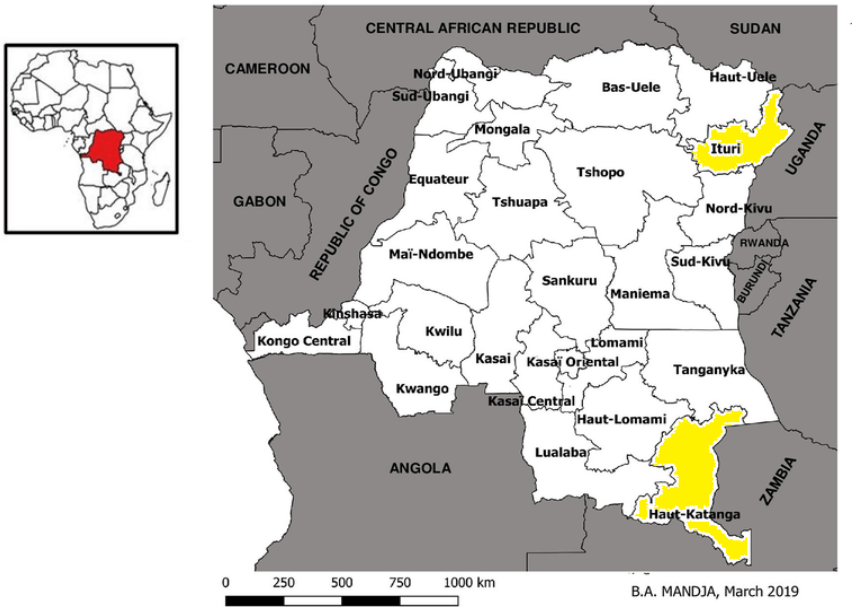


Fig: 20: Map of the Provinces selected for data collection

source: (https://www.google.com/search?q=drc+map+provinces)

Selected Provinces for data collection in the Kiswahili provinces

3.5.5 Data collection

The researcher got the authorization letter from the supervisor to collect data, and an authorization letter from the Ministry of Health DRC. A data collection sheet was developed by the researcher and approved by the supervisor. Contacts were done with principals of the schools (to recruit more children 3–5 and 15–25 years old), and also with pastors and Sunday school educators. The researcher explained the procedures to these people. After they had listened to the procedures, the young children (3–5 years) were gathered in one class/place and one of their teachers had to explain the procedures and show some pictures. Children were asked to say the names of the items in the pictures to help reduce the frustration and fear. Places or classrooms were arranged by either the pastors or principals of the schools and assign one person familiar to the children who acted as assistant researchers.

The assistant researcher (teacher/educator) presented the picture, one picture at a time, and the researcher plotted the answers on the data collection sheets. The responses were plotted in the form of a 'tally' and each picture was rated on a scale of 1 to 3 (1=highly recognized, 2=recognized with hesitation and 3=not recognized). For ethical reasons, for older people 40–70 years, the researcher had to explain the procedure and asked for their consent and availability to take part in the assessment.

For the construction of this test, this study followed all measures and criteria respectively (Coninx, 2005) according to the different precedents set in languages. The measures included: minimal influence of articulation, memory, vocabulary, visual cognition, word-image association (touch / click); closed format (n=6) / multiple choice; easy words word

material with redundancy as in everyday English life; and maximum contrast at the phonemic level with the trisyllables adopted in other languages, such as Dutch, French and Mandarin. Moreover, the automated adaptive procedures of 6 words were easy to handle, as well as the internal phonematic balancing, which constitutes a dynamic factor.

3.5.6 Construction of the 6-word AAST Kiswahili DRC version

AAST WORDS	Phonetic transcription	Tonal patterns	Images	English Words
SAMAKI	samáki	2nd (WSW)		Fish
KILATU	kilátu	2nd (WSW)		Shoe
MUKONO	mukóno	2nd (WSW)		Hand
MALAKI	maláki	2nd (WSW)		Beans
KIKAPO	kikápo	2nd (WSW)		Basket
MUPIRA	Mupíra	2nd (WSW)		Ball

Fig. 21: The Kiswahili AAST and phonetic transcriptions

Fig:22 &23 A final version of the constructed AAST Kiswahili version

3.5.7 Analysis of vowels and consonants distribution

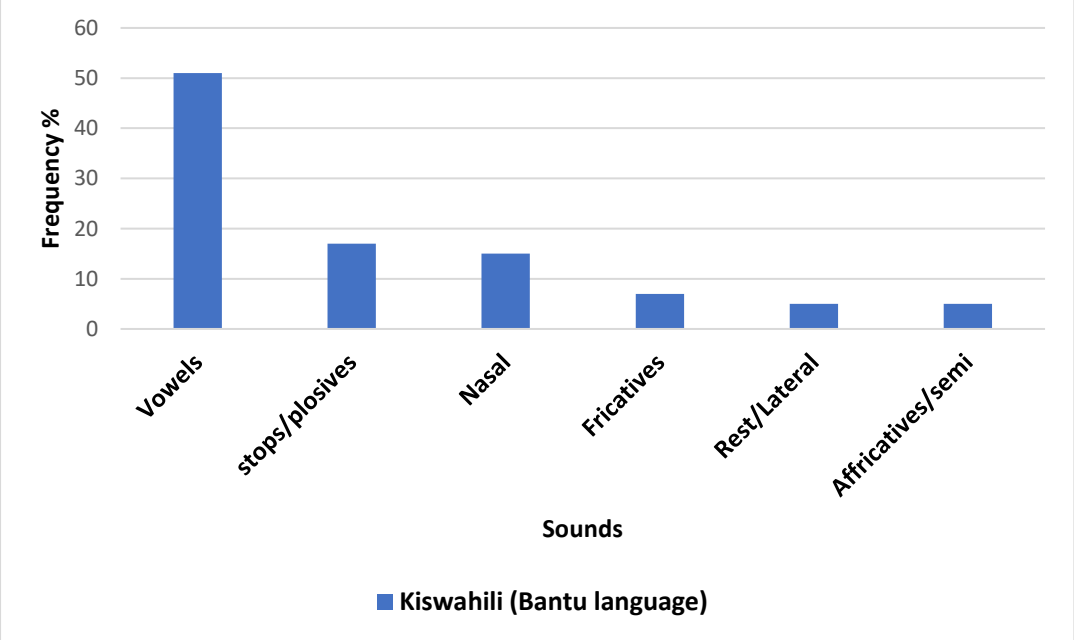


Fig.24: Kiswahili phonetic distributions

Swahili is a Bantu language and one of the national languages in the DR Congo .It is an official language in Kenya and Tanzania, as well as the lingua franca in many East-African countries, including Uganda, Rwanda and Burundi, some parts of Malawi, Somalia, Zambia, Mozambique (Lewis, 2009).

Table:12 Swahili consonant and vowels distribution (Lewis, 2009)

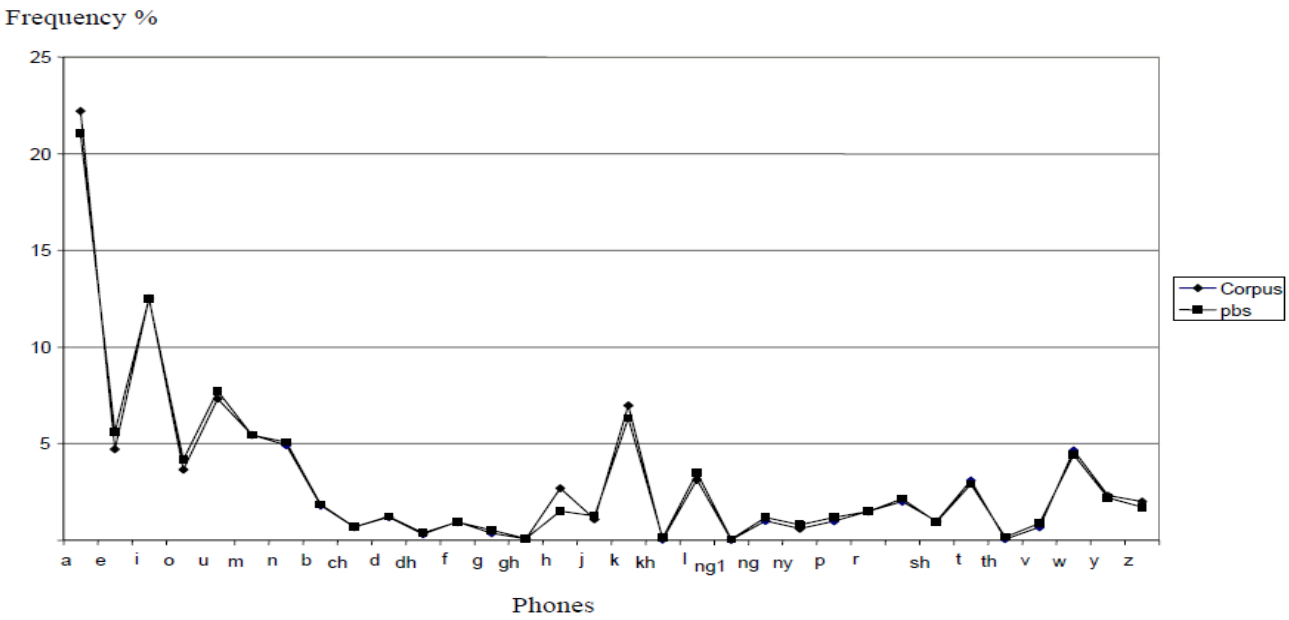
The Swahili Consonant system (Iribemwangi, 2010)

	Coronal					Dorsal				
	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Palatal	Velar	Uvular	Pharyngal	Glotal
Plosives	p b			t d		ɟ[1]	k g			
Nasals	m			n		ɲ	ŋ			
Trills			r							
Fricatives		f v	θ ð[2]	s z	ʃ ʒ		x ɣ[2]			
Affricates					ʧ					
Liquidae				l						
Semi vowels						j	w			

[1] *This symbol is used in Swahili transcriptions. The consonant sounds as a voiced affricate /ʤ/*

[2] *These sounds mainly occur in Arabic loan words and are not included in the test because of the low frequency*

Table:13 frequency distribution of kiswahili (Gakuru et al.2005)



3.6 Recording of noise and sound files

The AAST Kiswahili words were recorded in the radio studio Tangazeni Kristo in Bunia, DRC, using 2 females with clear, natural pronunciation and with an acceptable accent. A female voice was preferred for specific reasons.

- First, in comparison with the pitch of men and children, the fundamental frequency (F0) of the female pitch, as well as the formant frequencies (F1, F2), is 'in the middle'. Generally, F0-F1-F2 is lower for men and higher for children.

- Secondly, children have most experience with the voices of their mothers (female). So, internalized F1–F2 information is more familiar or established for female speakers.

- Thirdly, female voices are more soothing (Offei, 2013). The sound files were recorded in a soundproof room (with very minimal reverberation and ambient noise) with a high-quality microphone. The test was done in a quiet room (<40 dB SPL) a Kamplex KM-6 Sound Level Meter was used.

3.7 Norms and references values for validation of AAST Kiswahili version

3.7.1 Qualitative aspect of the AAST Test

A Qualitative observation was done specifically to observe certain behaviors before and during the test that can positively influence the test result in children; for example, curiosity or motivation to see the pictures, comfort or a stable emotion and understanding of the procedure of the test. Furthermore, some negative behaviors that can negatively influence the test result were also observed such as fear and non-motivation. Other aspects such as:

physical and health condition for example if the child has an associated disability, malnutrition, a behavioral disorder were also be observed.

A random selection of a few children with hearing threshold of 30-40 dB higher than normal was done, and were be subjected to an otoscopic and tympanometry examination. The tympanograms for both ears were conducted with a Grason-Stadler 38 Middle Ear Analyser. For otoscopy, an experienced ENT and audiologist inspected the external ear canal and the eardrum using a hand-held otoscope Heine mini-3000. This helped to identify children with either middle ear problem, Impacted wax or other health condition.

3.7.2 Group category

Children were selected from schools (nursery and primary) as well as from Sunday school from the different churches. Data were collected from 6 subgroup by age categories as follow in Table 14.

Table 14: subgroup by age categories

Groups	Age	Age category
Group 1:	4 y	3;0 - 4;11
Group 2:	5 y	5:0 – 5:11
Group 3:	6 y	6;0 - 6;11
Group 4	7 y	7:0 – 7:11
Group 5:	8 y	8;0 – 8;11
Group 6:	10 y	10;0 & above

In order to consider the learning effects, AAST data will be collected both in quiet and in noise. A randomized list of all children was done whereby all the even number had the first test in quiet on Right ear and all the odd had the first test on Left ear.

Every child passed 3 tests, meaning 6 subtests. The first test was done with the intention to give the child the option to learn what the test is about. The second and the third one was for data purpose.

3.7.3 Testing order for each child:

Table 15: For all the even numbers

subtest	**1**	**2**	**3**	**4**	**5**	**6**
Qt or CN	Qt	Qt	Qt	CN	CN	CN
side	L	L	R	R	R	L

Table 16: For all the odd numbers

subtest	1	2	3	4	5	6
Qt or CN	Qt	Qt	Qt	CN	CN	CN
side	R	R	L	L	L	R

3.7.4 Tools for data collection

For data collection, only the AAST Kiswahili from the Bells software was used for the purpose of the dissertation, for quality data, the Nuforce device was used with a volume control adjusted at the middle (50%) (fig 25) a headphone HD 280 PRO was used. Data were exported into csv files and bellsearch files and was sent to Ifap/Solingen for analysis.

Fig 25 Nuforce device with a volume control adjusted at the middle (50%)

3.7.5 The calibration file:

The uDAC3_HD280pro_20180919.TC6 has been selected from the CnF settings. As the test was to take place in a soundproof room, a laptop computer with the Bells software installed was used. Moreover, the use of 'headphones' during the test was designed and in the configuration box the headphone as **'transducer',** was selected and configured (fig26) and the headphone was connected to the uDAC3 during the actual test.

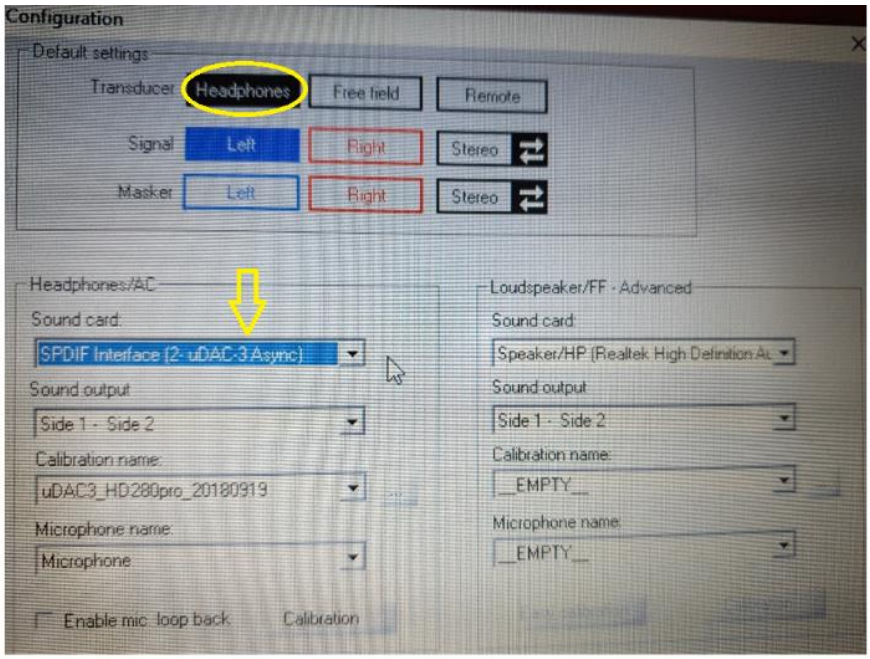


Fig:26.Configuration setting prior to the AAST Kiswahili test

3.7.6 Description of procedure before the Test (AAST)

Before starting the test, the identities of the participants were recorded, these are names, date of birth and gender. Each participant was registered under a number assigned as a personal identity. Before the test, the children were gathered in groups and were introduced to the pictures by their teachers in order to minimize fear and already familiarize themselves with the pictures. Also, since most children have never worn a headphone / earphone, even if the pictures are familiar, the fear of the earphone as something dangerous that can do harm remains observed. Thus, to reassure the children that the test is not harmful and also to concretize the procedures of pointing at the printed images when the stimulus is heard, the teachers were tested in the presence of the children.

At the beginning of the study situation, children were shown the six pictures of the test (Samaki, Mupira, Malaki, Kilatu, Kikapo and Mukono) and they were asked orally the meaning, this was to confirm their recognition of the picture. This part was followed by a detailed instructions and explanations of the test procedure used *"You will soon hear through the headphone the names of these pictures: Samaki, Mupira, Malaki etc. Please always point to what you heard on this card or repeat the name you heard, whatever faint is the sound, just pay attention and point or repeat what you hear''.*

At the same time, the child points or repeats, the tester clicks on the same picture on the computer and when there is hesitation without either pointing or repeating was assumed that the child did not hear the stimulus then, the tester clicks the question mark until the stimulus is heard and continue the process until it stops. All the children and few adults who took part in this test were exclusively Kiswahili speakers.

3.7.7 Description of procedure during the Test (AAST)

During data collection, the AAST test in Kiswahili version containing 6 words (Samaki, Mukono, Kikapo, Mupira, Kilatu and malaki) was printed in color on white A4 paper and

was laminated to keep the paper solid and Protect against dirt or tears. As for the mode or nature of the response to the stimulus, the participants had two options: First, it is a question of pointing the finger at the picture when the stimulus is heard. This option was more practiced by young participants between 6 and 10 years old and adults. Whereas, young children aged 3 to 5 years were more comfortable repeating the word heard as a stimulus. the total test duration per participant for both ears was approximately 5 minutes.

3.7.8 Test condition

All the tests were done in a soundproof room at Aru Audiology center located In the Northern of the DRCongo ,whereby the noise ambient is less than 35 dBA Sound level meter type Kamplex K-M-6 was used before the test and daytime to assess the background noise level.

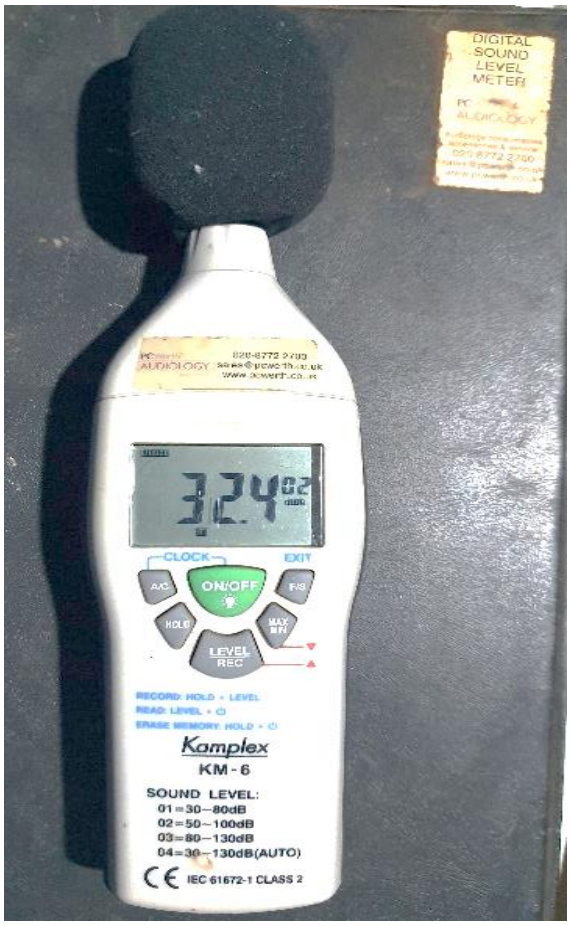


Fig27 Kamplex K-M-6

3.8 Results and interpretation

How can the AAST be adapted and used as an assessment and diagnostic tool to determine the SRT in children and adults in the DR Congo.

In order to build and adapt the AAST and use it as an assessment and diagnostic tool to determine the SRT in children and adults in the DRC, the 6-word AAST test in Kiswahili were constructed and adapted in accordance with the criteria initially established for the construction and validation of the first test in German and recommended in other previous languages.

Table 17: Gender distribution

Gender	Frequency	%	Valid %	Cumulative %
Female	68	52,5	52,5	52,5
Male	62	47,5	47,5	100,0
Total	130	100,0	100,0	

This table (17) shows that gender is relatively well distributed with (52.5 %) females and (47.5%) male..

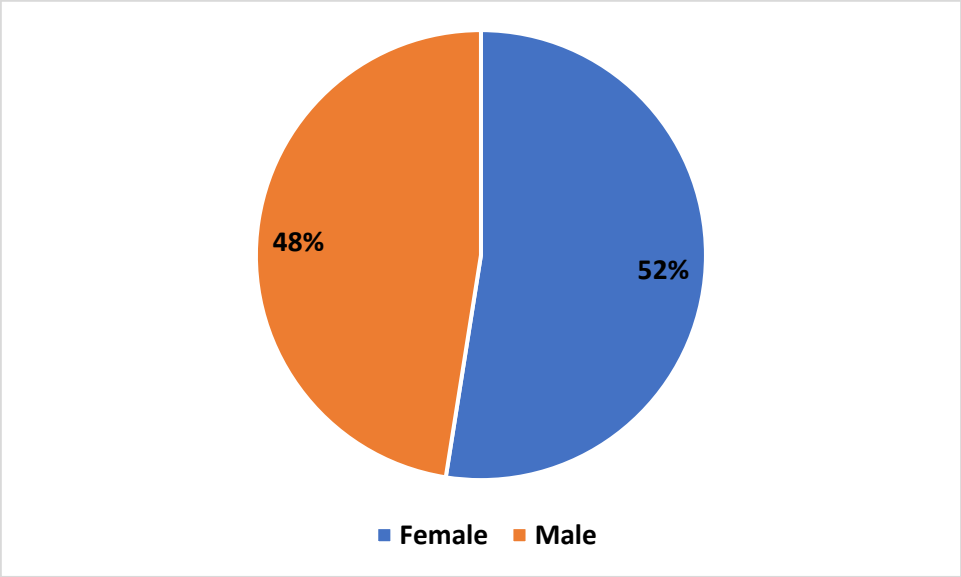


Fig: 28. Frequency Gender distribution

Table:18 Age distribution by group

Age_Categories	Mean	Min	Max
4	3.9	2.9	4.9
5	5.5	5.0	5.9
6	6.5	6.0	7.0
7	7.5	7.1	8.0
8	9.1	8.0	9.9
10	10.6	10.3	10.8
Youth/Adult(11-40)	25.6	11.9	36.3

The minimum age as shown in this table is 2 years and 9 months and the maximum age for group of 10 years is 10 years and 8 months which is in line with the AAST validation requirements.

RQ *1* ***What are the behaviors before and during the AAST test that can positively or negatively influence the results of the test in children ?***

In this same perspective, different behaviors of fear, agitation, sometimes refusal and lack of collaboration for some children were observed, even though they are active and diligent children in class. these behaviors were observed more in young primary school children between 7 and 10 years old, while children under 5 years old were calmer but with short attention span and less concentration during the test. Three (3) children in the category of 3 years old were affected by sleep, they felt asleep during the test on the second ear.

In addition, out of N=65 children tested whose age varies between 7 – 10 years old, the results of audiograms of thirteen children n=13, (20%) show the reception threshold (SRT) slightly elevated between 25 - 35dB SPL. This short attention span was the reason to reduce the number of the tests to 4 or 5 instead of 6 in some children below 5 years. (see ppendix…)

RQ 2 What are the age-dependent normative values for the AAST Kiswahili versions, in comparison to other AAST versions?

AAST norm data were collected from N=120 (male: n=57; female; n=63) children with ages ranging from 3 to 10 years old. The average ages and SDs of the participants and their corresponding age groupings are shown in tables 19.

3.8.1 Normative values in quiet

Table :19. Mean, Minimum, Maximum Thresholds, Standard Deviation in Quiet across age groups

Age_Categories	Mean (dB SPL)	SD	Min (dB SPL)	Max (dB SPL)
4	40.1	8.6	22.4	68.2
5	29.9	6.0	19.0	45.7
6	30.2	7.2	19.0	52.4
7	30.2	4.3	22.4	37.4
8	30.6	5.5	19.4	49.0
10	28.1	5.8	22.4	40.7

In this table, it is observed that the Mean and the Standard Deviation decrease as the age increase

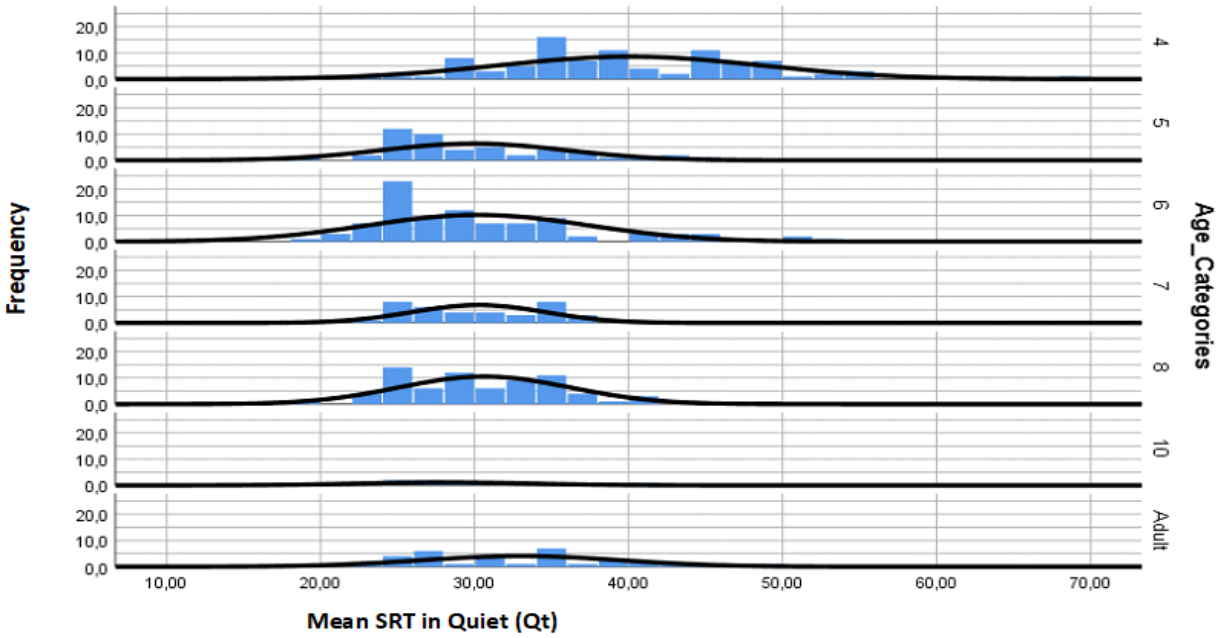


Fig 29: Mean SRT in Quiet across age groups

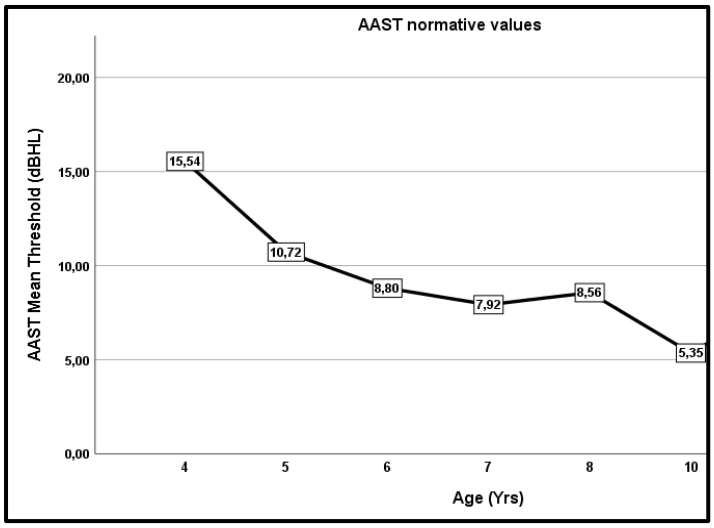
This fig.29 shows the same as the table above. For age category 4, mean is 40. For the other age categories, mean is around 30. In age category 4, SRT is most dispersed, distribution is the most wide. In the other age categories, SRT is more close together.

3.8.2 Standard values

This study shows that the AAST test can certainly be adapted and used from the age of three to four years for the Kiswahili version as the literature and experience indicate in several versions. About 4 minutes are needed for a complete test. Furthermore, it is apparent from this study that the results are normally distributed and the mean values per year have been summarized for the 6 groups. (Fig. 1).

Normal values for children at age four are about 10 dB higher than for adults and steadily decreasing for age eleven and older. these processes find an explanation scientifically observed in almost all versions in different languages that, as the age increases there is an increasingly better concentration as well as increasingly developed top-down perception strategies. Moreover, for the AAST Kiswahili compared to other versions such as the German version, Malta, Poland, Ghana, there is a slight difference in the average dB values which are a little high for the groups of ages 7-8 years old.

Possible explanations would be that, out of N=120 (100%) of participants who took part in the test during data collection, n=65 (54.1%) of children/participants between 7 and 11 years old had several other health and/or psychological conditions. The details are explicit in sub-question number 3.



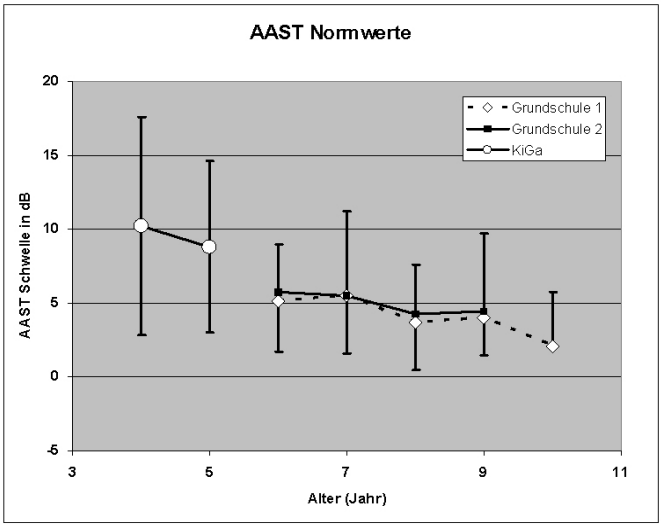


Figure 30: Age dependent comprehensive norm curve for AAST Kiswahili DRCongo

Summary of Mean values foe the AAST Kiswahili

Fig:31. Summary of Mean values for the Germany version

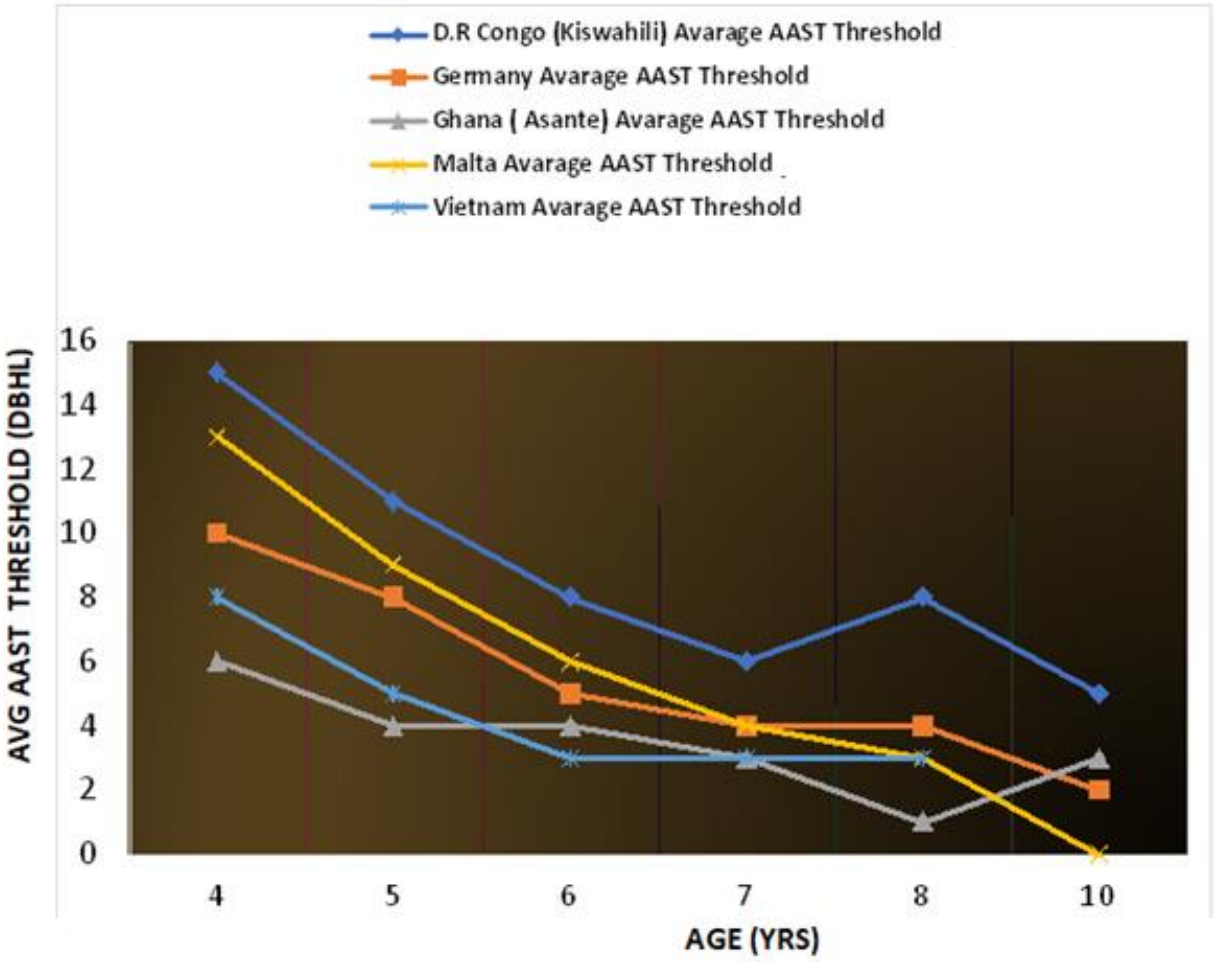


Fig:32. Age-related norm values in AAST across languages in comparison to the Kiswahili (DRCongo) version

This figure (32) shows, there is an age dependent threshold difference of about 10 dBHL between younger and older children for the DRCongo AAST Kiswahili version, which is similar and comparable to other findings plotted such us for the Germany original version about 8 dBHL differences, the Malta version about 13 dBHL difference, the Vietnam and Ghana version about 5 dBHL difference.

One more thing is that the Kiswahili threshold is slightly higher than for other languages, for every age category. This slight increase in the average value can be explained by the variation in environmental conditions and also the physiological, emotional and psychological

predispositions of individuals. this hypothesis can be tested in another environment in a future study.

Surprisingly, the AAST test in Kiswahili version in comparison with the AAST Polish and Vietnamese version, these two versions (Polish and Kiswahili) are almost similar despite the slight difference for the age group 4 and 8 where the Kiswahili version is slightly high.

A possible explanation would be that the Polish AAST version has 4 words, and about 20% of children under 5 years old tested for the AAST Kiswahili version had taken 4 tests instead of 6 as planned because of their short attention span.

Compared to the age group 8, approximately 54.1% of children between the ages of 7 and 11 were observed having several other health and/or psychological conditions that could influence and contribute to this variation in threshold compared to other versions of AAST in different languages. This comparison is shown in fig:33.

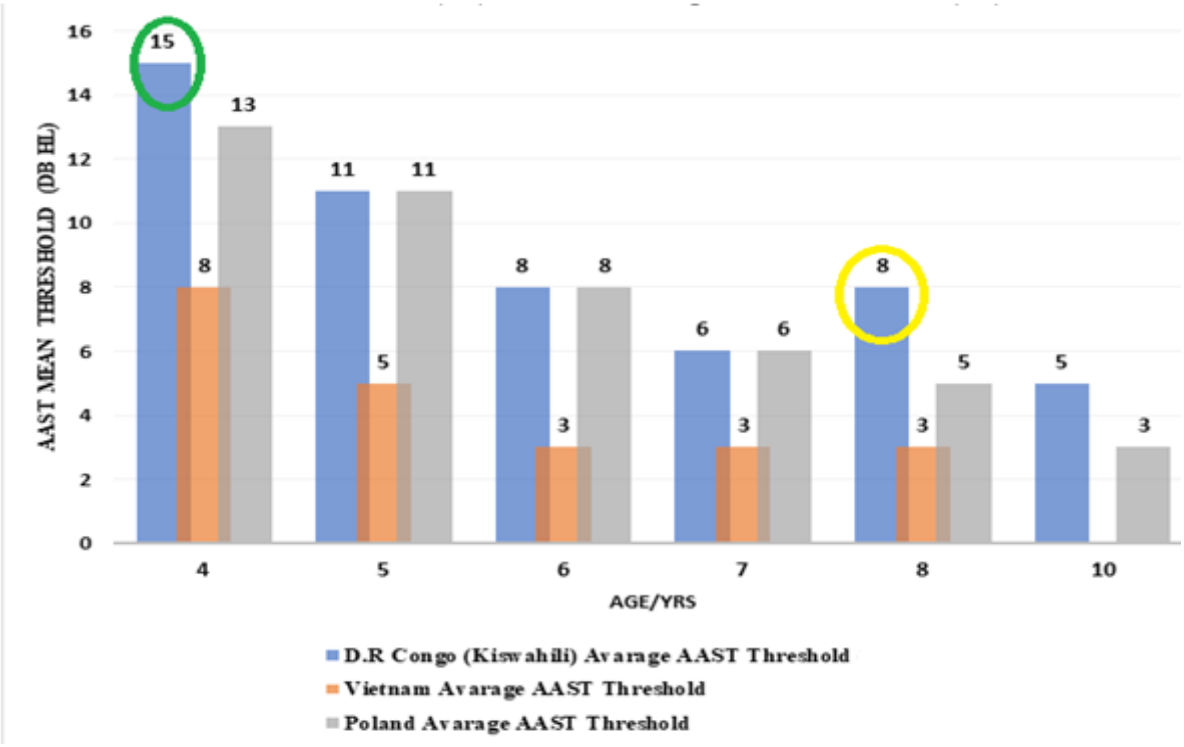


fig:33: Similarity in the AAST Kiswahili Average threshold and the Polish version

3.8.3 Reliability

As part of identifying the reliable effects of this AAST test in the Kiswahili version in comparison with the original Test in the German version, a linear table (20 & 21) shows that the two factors (Age and AAST mean threshold) are associated as age increase the SRT decrease, which occurs in a non-intuitive sense. However, since age and AAST SRT are strongly correlated, which is observed by the points within the range of the model, this reflects a good reliable prediction of the response and the characteristic of the data. For both AAST tests, it is observed that the predictors are strongly correlated, as the values of the predictors tend to fall in a straight line. This support that the test results for both German and Kiswahili version of the AAST have been stable and consistent.

Table 20: D.R Congo (Kiswahili) Average AAST Threshold (dBHL) appear highly correlated.

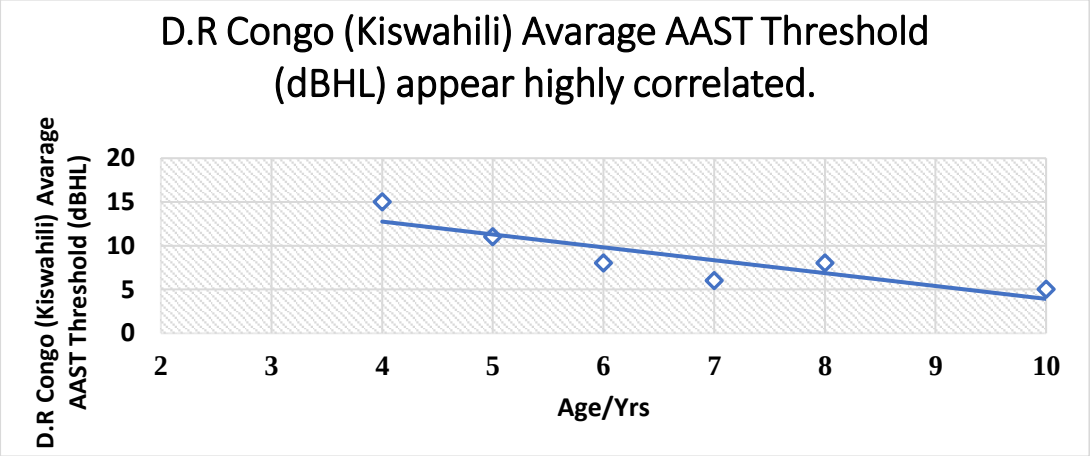
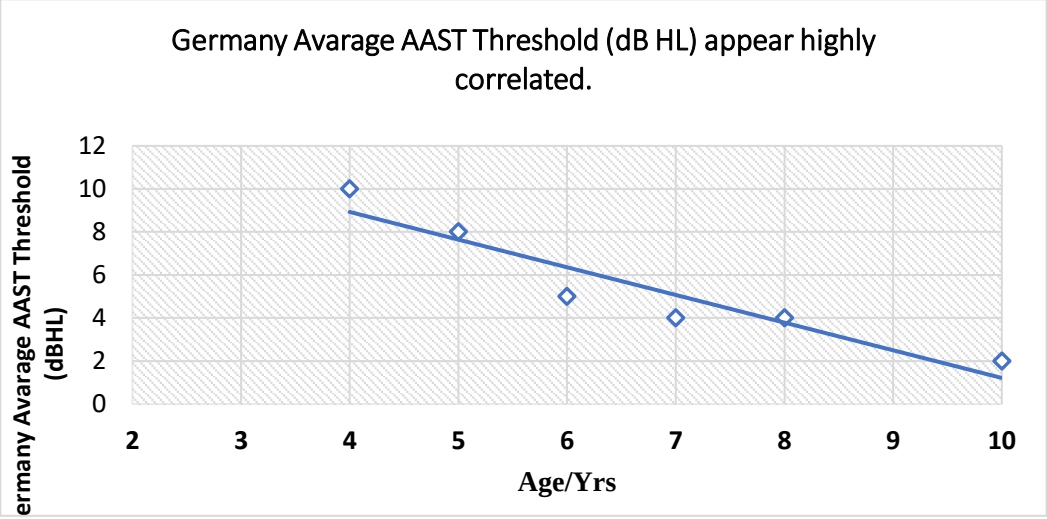


Table 21 : Germany Average AAST Threshold (dB HL) appear highly correlated.



3.8.4 Normative values for Adults

In the following figure there is also a slight increase in the average values for the age group 11 to 40 years (Fig:34). A possible explanation would still be the presence of a few young

people with a middle ear problem and cough which would be suspected as an episode of Corona virus Omicron". This hypothesis will be further tested Omicron". This hypothesis will be further tested.

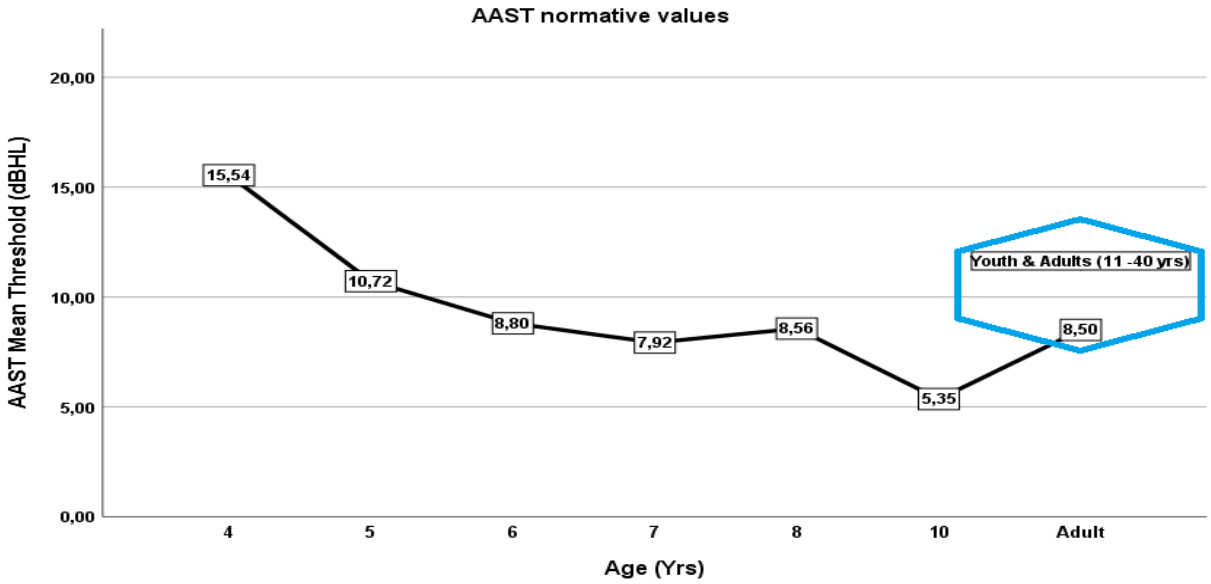


Fig 34 **Norm values for Adults**

RQ.3: Are children with thresholds 30-40 dB higher than normal having middle ear problems or other health condition?

During the data collection, after the AAST test, all the participants underwent an otoscopic examination by an ENT doctor and an examination of the middle ear whereby the middle ear analyzer (tympanometry) was done for all the participants whose hearing threshold was high between 30 - 40 dB.

From N=120 (100%) aged from 3-10 years old of participants in the AAST test Kiswahili version during data collection, n=65 (54.1%) of children between 7 and 10 years old had several other health and/or psychological conditions. It was observed, out of N=65 (100%), 2 (3%) participants had unilateral impacted wax , 6 (9.2%) with middle ear problem whose

tympanometry results revealed an OME with a type C tympanogram, 4 (6.1) of the participants had some behavioral disorder and had been epileptic for more than 5 years, 1 (1.5%) was a child who stuttered. 11 (17%) of participants had simple cough with less middle ear problems but had slightly higher threshold of about 25 to 35dB. This is represented in Fig:35.

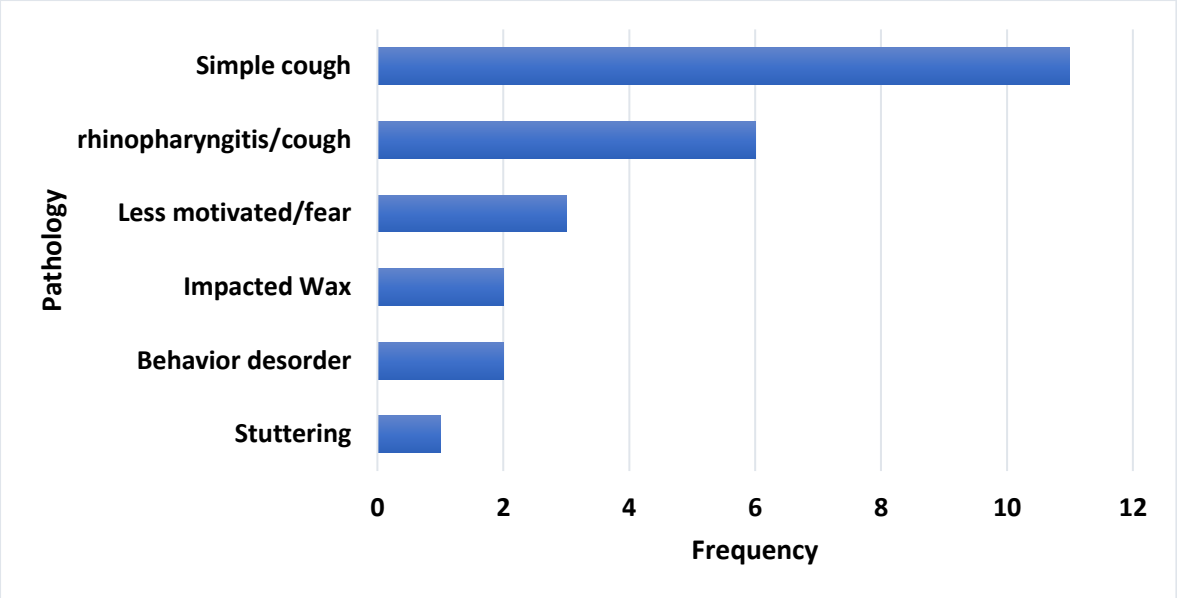


Fig:35 'Pathology': Simple cough has noticeably higher 'Frequency'.

Looking at the fig:36, the bar chart shows some children in the 3-4 year age group (4.1%) of N=120 were children affected by coughing and some hypersensitivity behavior. This could justify raising the hearing threshold in this age group. Similarly, between the age group 7-10 years, 17 (25.5%) participants had middle ear problems and others were affected by dry cough with less middle ear problems after a middle ear analyzer test but with hearing threshold elevation of more than 25 dB shown in the AAST audiograms. The health condition especially which involve the ear and the nasopharynx sphere would be the cause of the variation leading to the increase in hearing threshold for this age group between 7-8 years.

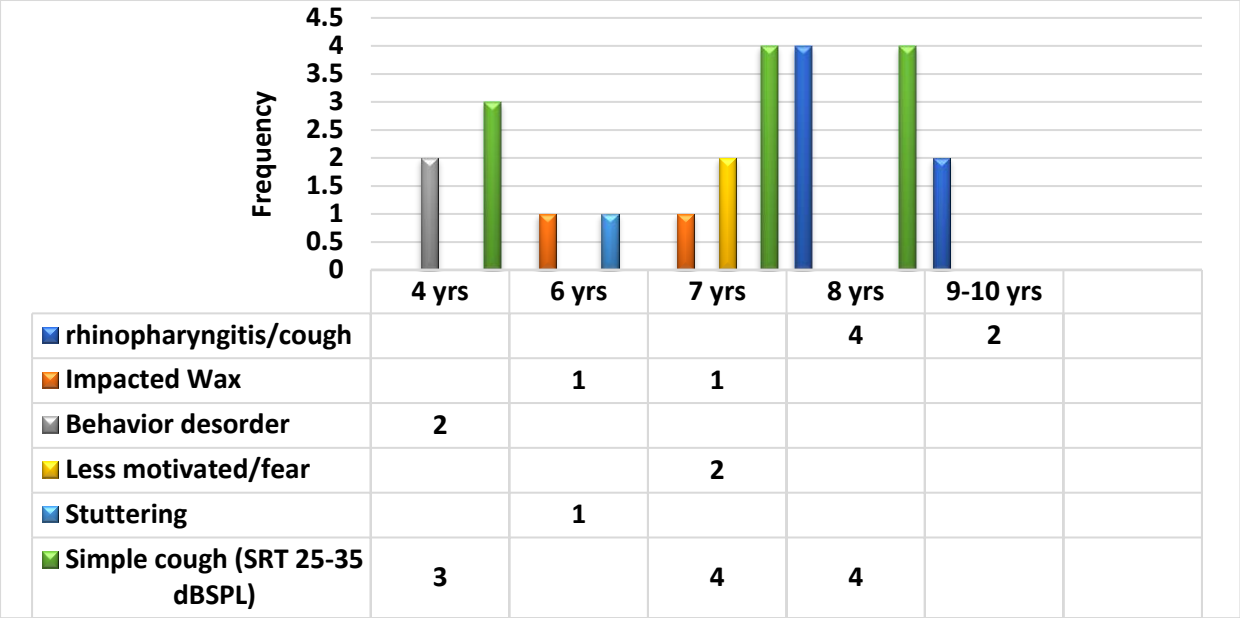


Fig:36 Pathologies by Age category

3.8.5 Normative values in noise

Table: 22. Mean, Minimum, Maximum Thresholds and Standard Deviation in Noise across age groups

Age_Categories	Mean	SD	Min (dB SNR)	Max (dB SNR)
4	- 11.9	4.00	- 20	- 5
5	- 14.8	4.50	- 21	- 2
6	- 14.9	4.10	- 23	- 2
7	- 15.6	3.70	- 21	- 7
8	- 16.6	3.20	- 23	- 6
10	- 14.8	4.90	- 22	- 6
Youth/Adult(11-40)	- 16.0	3.40	- 21	- 8

This table shows that as age increases, the mean decreases, from -11.9 for 4 year old to -16.0 for 10 year old. Standard deviation (dispersion) also becomes smaller, so scores are closer together for older children than for younger children. The Same information in Fig:37 but graphically represented.

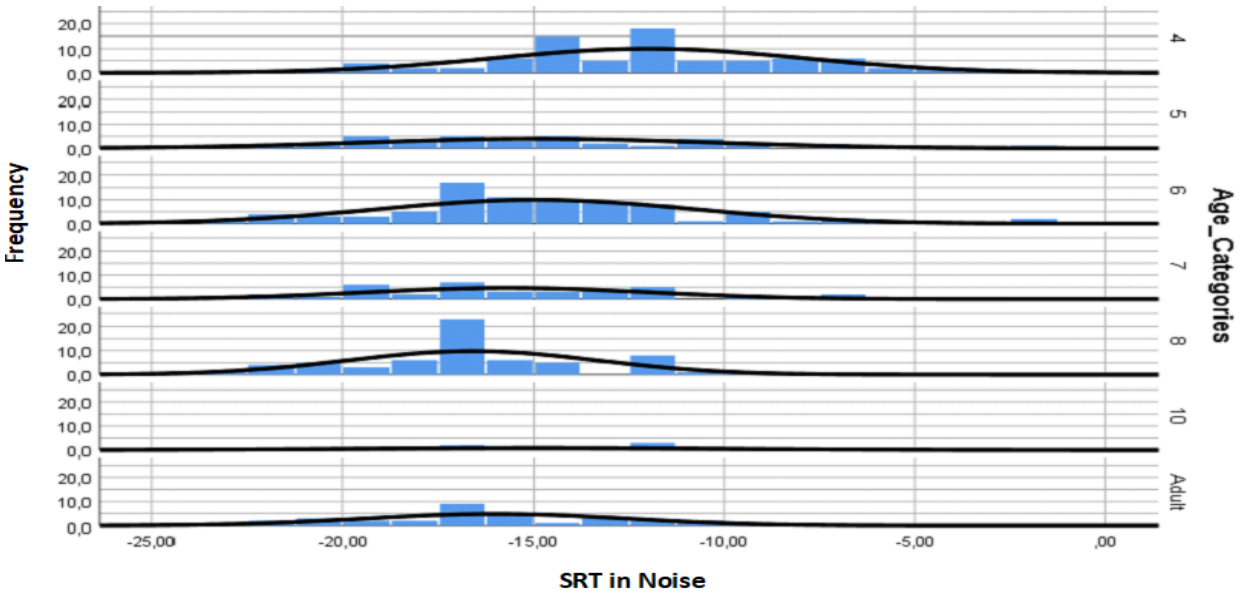


Fig:37. Mean SRT in Noise across age groups

Distribution of response time across the age categories in Qt and in Noise

Table:23. Mean Response Time by Age Category

Age_Categories		Mean (seconds)	SD
4 yrs	Quiet	3.8	1.8
	Continuous	3.2	0.8
5 yrs	Quiet	2.6	1.0
	Continuous	2.4	0.7
6 yrs	Quiet	2.6	1.0
	Continuous	2.4	0.6
7 yrs	Quiet	2.7	1.1
	Continuous	2.5	0.7
10 yrs	Quiet	2.8	1.0
	Continuous	2.7	0.7

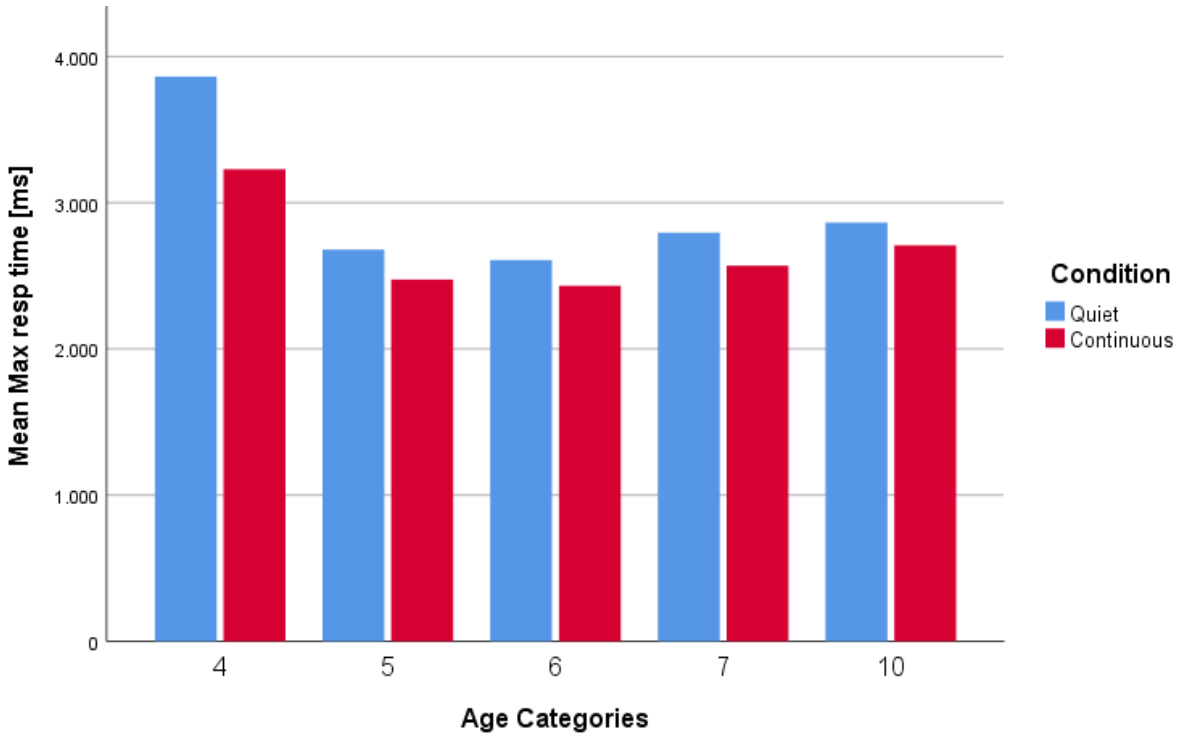


Fig:38. the Mean response time by age categories

The information presented in table 23. and the bar chart fig:38. show that, the response time gets quicker for older children. Slowest response time is for the 4-year-old, quickest response time is among 6-year old. Possible explanation is that the younger the child the lower the top-down perception strategies is developed.

RQ.4 What is the learning effect of the AAST test words in the Kiswahili language ?

Many factors that interfere with the learning effect, attention, motivation and emotions are manly the most important. In everyday life in local and semi-urban areas, “Samaki (fish) and Malaki (beans) are two staple foods. Children see them and eat them almost every day and this constitutes in their cognitive ability a good recognition of the word emitted as a stimulus in the context of the AAST test. While Kilatu (shoe), Mupira (ball) and Kikapo (basket), children in their vulgar language, often have other pseudonyms such as Kilatu (Shoe) some

children call << ketch, wazekwa, machuda etc), Mupira (balo, bale,) although they recognize that this picture is Kilatu or Mupira in Swahili, but the time they may take processing to separate the real name from the nicknames, like in this condition of this AAST test, whereby the neurons of the visual form area of the Words slow to distribute visual information to many regions of left hemisphere for recognition, create slight delay in word articulation that is emitted as stimulus. This learning effect in the recognition process is presented the fig:39.

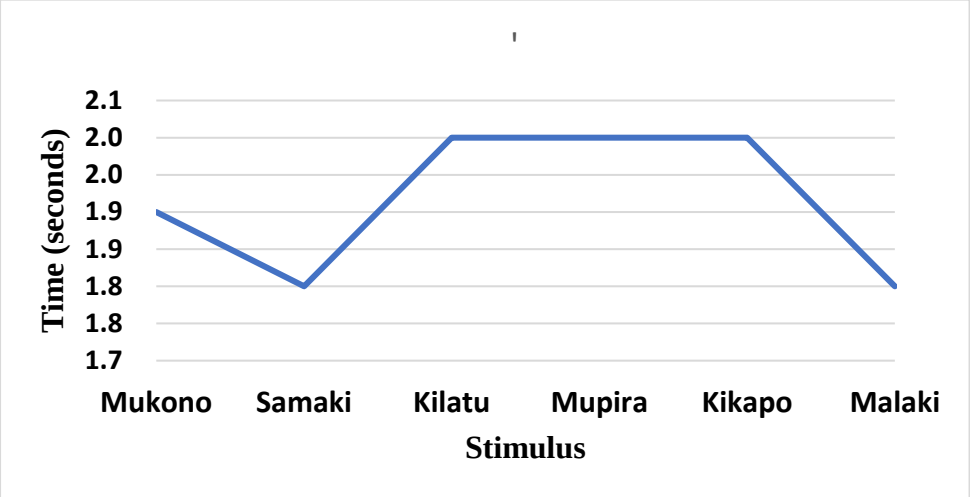


Fig:39. Time (seconds)' by 'Stimulus

3.9 Discussion

RQ1. The results of the study suggest that AAST can in principle be used in children at the age of 3 and 4 years (Coninx 2005) and also in preschool age i.e. in children aged 5 to 6 years (Hoffmann et al. 2018). During the test, about 3 or (2.5%) children did not complete the 6 planned tests because of the reduction in their attention during the test. This similar situation was observed by Hoffmann et al. (2018) in a study on the application of AAST in children at preschool age that limitations in the attention span, short-term auditory memory, poor concentration and, in some cases, behavioural problems can occur.

However, the prevalence can only be estimated cautiously and is around 2–3% in children Hoffmann et al. (2018). A study of the short version of the AAST test would be possible in a purely African context where this low attention can be associated with the physiological state, for example in rural areas some children go to school without breakfast or have a poor diet as a result may have less energy.

Another important element in this study is the observation of the fear of headphones because children have never seen. This fear of an unknown instrument creates a certain discomfort in the child, therefore a spirit of refusal is created. Acceptance of the procedure by the child is an essential basis for the test results to be usable and reflect the actual performance of the test.

Hoffman et al. (2018); Feniman et al (2007) & Natacha (2002) confirm that, an attractive design of test materials with an incentive character in the form of action tasks have a positive effect on the child's motivation during the test. That is, knowledge of the test equipment or

materials can create a stress-free atmosphere and can reduce the influence of error sources such as unwillingness to cooperate or fatigue on the test result. (Hoffmann et al. 2018)

Although the AAST test is attractive because of the well-known and well-familiar pictures the child, but the fact of never seeing and never wearing the headset can compromise the passing of the test and even have the negative effect on the results. In the villages, most of the children are used to the loudspeakers which they see every Sunday in their churches, functions etc which they recognize as the only source or instrument where the sounds come from. Therefore, the suggestion of conducting the AAST test in the free field in young children may be well accepted in some rural settings compared to those in cities where children are exposed to technology earlier enough.

RQ2. The AAST test has been constructed and validated in more than 10 languages (Coninx, 2005), but remains less known on the African continent (Ofei 2013), particular in French-speaking countries in Central and West Africa. As part of its extension to other regions, possibly internationally, the adaptation of this AAST test is important for the African context where the majority of countries do not have an early detection program implemented for prevention of deafness in their primary health care system.

Thus, the objective of the present study was to construct and validate the AAST test in Kiswahili version in the DR Congo, a test that can be carried out easily and efficiently on children at the age of 3 to 4 years and older, and could be substituted as a complement to other universal tests, as an early screening method, to identify children with hearing impairments.

To respond to this sub-question, the AAST Kiswahili version, a computer-based speech audiometry test has been constructed and validated, that can be used as a screening and diagnostic tool to adaptively determine the SRT in quiet and in noise. The normative data for this first version in Kiswahili DRCongo has been provided. The sample included 130 participants out of which 120 (92 %) were children from 3 to 10 years old. The AAST Kiswahili version has proven to be very practical because children at the age of 3 understand the task easily because they are motivated by the recognized pictures that are more familiar to them, and also by the procedure in the form of a game adapted to their age. This version of AAST Kiswahili lasts about 5 minutes in total for both ears, which is comparable to almost all the other versions (Coninx, 2005; Ofey 2013; Miggiani, 2021). Therefore, detecting minimal hearing loss at kindergarten age is easily possible with AAST kiswahili version.

Another important finding in this study is that the normal values for children at the age of four are about 10.2 dB higher than for adults which is comparable to the original German version. Meaning that, older children perform better than younger children. Additionally, at the national scale, the use of AAST Kiswahili version, could benefit many children and adults in the DRCongo who speak Kiswahili as their second and third language. which makes the AAST test in Kiswahili version a necessary tool for early detection, adapted to the needs of children in different language groups in Congolese society.

As Ofei (2013) said "Ghanaian children love to play on the computer". Similarly, Congolese children in town like to play on the computer too and in rural areas like tangible pictures, such as the printed pictures of AAST. This attraction to pictures constitutes an opportunity and reinforces the motivation of children to take part in the hearing screening test. This acceptance may facilitate the integration of AAST test into the primary health care system, and also into the educational setting for the early identification of hearing impairment. this implies that, the

AAST test in Kiswahili version adapted for the first time in the DRCongo during this study, will serve as a basis to improve the level of early identification.

Besides the important characteristics of the AAST test validation according to the standards (Coninx, 2005; 2007), an important conclusion of this study is that the AAST test in Kiswahili can be considered as reliable tools for screening children not only in the DR Congo but with possible extension in neighboring countries, where Kiswahili is spoken those inlcude Zambia, Burundi and some parts of Rwanda and Tanzania. This multilingual character proves the linguistic adaptation of the AAST test to meet the needs of the different layers of the population both in rural and urban areas (Coninx, 2005).

RQ3. With regard to the evaluation and interpretation of the results, many screening procedures only offer initial information such as “pass” and “refer” after they have been carried out (Hoffmann et al. 2018). But, The AAST method has proven to be very practical. The dispersion of the standard values and the test-retest reliability of less than 5 dB make that even minimal hearing losses of 10 dB to 30 dB can be reliably recorded. Thus, the detection of minimal hearing loss at the age of three to four years and older is easily possible with AAST (Coninx, 2005). This is in line with the results from the current study whereby, some children in the 3-4 year age group (4.1%) of N=120 were children affected by cough which is considered as an upper respiratory track symptoms that usually affect the inner ear, thus creating a mild hearing loss.

Surprisingly, between the age group 7-10 years, 17 (25.5%) participants had middle ear problems after an otoscopy and a middle ear analyzer. This health condition especially which involve the ear and the nasopharynx sphere would be the cause of the variation leading to the increase in hearing threshold for this age group between 7-8 years. So, these two independent

tests (AAST and the tympanometry) have agreed though they complement each other in the diagnostic process.

Therefore, the outcome of this study confirm that, the AAST Kiswahili version is suitable as a screening method to identify hearing loss in children at the age of 4 years and older, and constitute a key for referral of any abnormality to carry out a detailed diagnosis and to intervene early with therapeutic and pedagogical measures (Hoffmann et al. 2018).

3. 10 Summary & conclusion and rcommendations

3.10.1 Summary

There are historically many tests developed and used to diagnose hearing loss and most of these tests have been developed in English, and therefore the adapted versions of them have been developed by several countries in their national languages. The AAST has already been adapted in several languages. In the DRC there is no literature to be found about the adapted version of the AAST. In the DRC, there are 4 majorly used and understood languages and the 5th which is French, is the official language for communication and is understood by over 80% of the Congolese. Additionally, about 40% of the Congolese population can express themselves in Kiswahili, which makes it the most spoken language of the country, mainly in the eastern provinces: North and South Kivu; Maniema; Katanga; and Ituri Province, formerly Orientale.

This chapter was aimed at determining how the AAST can be adapted and used as an assessment and diagnostic tool to determine the SRT in children in the DRC. As such, 6-word AAST tests in in Kiswahili was constructed and adapted in accordance with the criteria initially established for the construction and validation of the first test in German and

recommended in other previous adapted languages. This confirms that, the versions of the AAST test in Kiswahili can be considered as reliable tools for screening children in the DRC.

3.10.2 **Conclusion**

The goal of this study was to construct and validate the Kiswahili versions of the AAST for children aged 3–4 years and older. A new and first-computerized closed set of the AAST has been developed in Kiswahili, one of the four national languages in the DRC. The first closed set of a 6-word AAST was developed which meet the needs of the different layers of the population both in urban and in rural areas. As the first hearing screening test in the country, this implies that the AAST will be used as a screening and diagnosis tool for hearing loss in the DRC because it is a user-friendly and adaptive tool, and also as a screening tool in infants as an alternative to the UNHS programme.

3.10.3 Recommendations

Besides the validity of the AAST, which is also preserved by the fact that the AAST word sets for each language are limited to 6 words, and the word selection criteria is typically the same for each language-specific test, the adaptation to 4 words can also be explained in the African in order to minimize the errors that can occur due to short attention span. A short duration test is in line with guidelines for hearing screening in the school setting that hearing screenings should be done in a short amount of time (Coninx, 2008; Coninx et al., 2009).

The DRCongo is a huge country with 4 national languages. The adaptation of the AAST in Lingala could be beneficial for about 40 to 45 million of population. This will be a high achievement to have available screening tool to cover about 80 % of the population.

CHAPTER FOUR: INTEGRATING THE LittlEARS AUDITORY QUESTIONNAIRE (LEAQ) AND ADAPTED AUDITORY SPEECH TEST (AAST) AS HEARING SCREENING TOOLS INTO COMMUNITY-BASED REHABILITATION (CBR)

4.1 Introduction to CBR

After the 1978 Alma-Ata Declaration, the WHO initiated the concept of CBR as a model to help address social, physical and cost barriers among people and their families living with disabilities in accessing health services, in a bid to realize the ambitious goal of 'Health for All' (WHO, 2010; Helander, 2007; WHO, 2004; Asher et al., 2015; Lukersmith et al., 2013).

Over the decades, there has been increased adoption by governments, local communities and NGOs in utilizing a CBR approach as a strategy within the general community in addressing the service needs of people living with disabilities (Finkenflügel, Wolffers & Huijsman 2005; ILO, UNESCO & WHO, 2004; WHO 2003). Despite the increase in the use of CBR and its diversity of strategies, as depicted by the WHO (2008) to leverage support and interventions for people living with disabilities, its adoption in early intervention for children with a hearing disability has been limited, especially in low- and middle-income countries (LMIC) (Maluleke, Khoza-Shangase & Kanji, 2019; Hussein et al., 2018). Moreover, it has been documented that institutional-based rehabilitation initiatives have been incapable of addressing the rising needs of the population. Thus, this has opened the way for a CBR approach (Thammaiah et al., 2017; WHO, 2010), which aims to transfer basic rehabilitation skills from rehabilitation professionals to primary health care (PHC) workers and less-specialized practitioners, as well as the streamlining of referrals to more specialized rehabilitation services external to the community (WHO, 2018a).

4.2 The role of CBR intervention for children with hearing loss

Rehabilitation is a set of interventions that can be designed to optimize functioning and reduce disability in individuals with health conditions, and it may be needed by anyone with a health condition who experiences difficulties, such as hearing loss. When integrated into PHC, rehabilitation services may be provided by primary care workers, such as general practitioners, primary care nurses or CHWs (WHO, 2018a).

In terms of hearing, rehabilitation can be viewed as an essential component of management of children with hearing loss (WHO, 2018b). Rehabilitation for children with hearing loss has been given much attention in the recent decades along with the application of CBR for them (Olusanya ,2008; McPherson, 2012; WHO, 2012; Karanth, 2010). Hearing loss does not only impact the individual with hearing loss but also the individual's family and community and because of this, any response to the needs created by the hearing loss will be more effectively addressed in a community-based approach, in other words through CBR (WHO, 2012).

CBR is thought to play an important role in early intervention for children with hearing loss (Dobrow et al., 2018; Maluleke et al., 2019; Ramkumar et al., 2019; WHO, 2012). The critical areas where CBR is thought to have played a pivotal role for these children include: creating awareness about hearing loss and available hearing care, identification of children with hearing loss, referring children with hearing loss for tailored care and support, active case management for children with hearing problems, language and speech development, auditory rehabilitation, advocacy and resource mobilization, hearing aid provision, inclusion of people with hearing loss in decision-making and carrying out research on hearing loss (WHO, 2012).

Ramkumar et al. (2019) implemented a community-based hearing screening for infants and young children in rural India, and the programme resulted in 77% of the children screened for hearing loss in the targeted villages. In this study, village health workers (VHWs) were required to refer children identified with a hearing problem or risk factor for hearing loss for further professional evaluation (what the researchers called a 'second screening').

The professional evaluation was carried in 2 different arms, community-based telemedicine and in-person hospital-based screening. When Ramkumar et al. (2019) compared rates for follow-up (community-based versus hospital-based) for the second screening, community-based follow-up resulted in 11% better follow-up compared to in-person hospital-based follow-up.

In South Africa, CHWs were involved in community-based hearing screening using an mHealth delivery model for a period of 12 months, and the programme resulted in 6,424 preschool (3–6 years) children screened for hearing loss (Hussein et al., 2018). In another part of South Africa, it was found that children identified with hearing loss and enrolled in EI were identified late compared to the benchmark of developed world standards (Maluleke et al., 2019).

Similar findings were also reported in a systematic review conducted to assess disparities in access to paediatric hearing healthcare (Bush, Kaufman & McNulty, 2017). The results indicated that children with hearing loss from certain geographic regions or ethnic backgrounds are significantly delayed in diagnosis and treatment. The authors reported that the attributable factors for the delay to diagnose and treat hearing loss in children were related to some extent to patient characteristics and parental factors such as lack of information, and lack of screening programmes and expansion of care through remote services were also thought to play significant roles (Bush et al., 2017). This shows the

importance of the CBR program in some specific areas to back up the PHC services accessible to all.

In a qualitative study designed to assess the rural perspectives and experiences with early infant hearing detection and intervention, the participants of the study reported difficulty in accessing hearing tests and conflicts with family and work responsibilities, and the authors therefore recommended a community-based approach for hearing tests (Elpers, Lester, Shinn, & Bush, 2017).

In Guangdong, China by Liu et al. (2019) developed a community-based hearing care service model, which they integrated with multiple maternal and child health programmes, and a series of clinical activities for preventive and treatment interventions to take place. Overall, this model led to early diagnosis and management of children with hearing loss or risk factors, appropriate referrals and follow-ups, increased awareness on hearing loss and knowledge on hearing care services, early risk management for children with hearing loss risk factors, and better risk reduction strategies (Liu et al., 2019).

Despite the promising role of CBR, there is still limited evidence regarding its effectiveness in early identification and intervention for children with hearing loss (WHO, 2018a). A major challenge commonly reported by studies on CBR interventions is the problem with referrals and follow-up for children who need further support and / or evaluation (Ramkumar et al., 2019; Hussein et al., 2018). For example, Ramkumar et al. (2019) reported in their study only a 0.8% referral rate and a significant number of children (20%) failing to attend their follow-up appointments. On the other hand, Hussein et al. (2018), reported more than half of children (60.6%) referred by VHWs after community screeing failing to attend their follow-up appointment at a local clinic.

It needs to be considered, however, that the literature comes mainly from developed nations with different methodological approaches. Secondly, there are serious discrepancies in the evidence on the role of CBR. Therefore, there is the need to do more research with a similar methodological approach in a different context, such as in the DRC, to support the arguments for CBR for children with hearing loss.

Since 1998, a CBR programme has been running, not only in the city of Kinshasa (Kilangalanga et al., 2019), but also in the eastern part of the DRC, with the aim of supporting people with disabilities in the community, especially those with physical; visual, hearing and intellectual disabilities, including other chronic and neurologic disorders, such as epilepsy (Byaruhanga, 2015). The CBR programme mainly focused on community identification, home visits, referral of people in need to appropriate health facilities, home-based care, and their integration into society.

In the DRC, although the CBR programme is housed at the Ministry of Health, its action on the ground and its applicability is more developed through churches, especially the Catholic Church with staff as volunteers on a charitable basis. These volunteers have been trained and directed towards early identification and referral of children and adults with blindness and visual loss in the community, especially those suspected of having cataracts (Kilangalanga & al., 2019). Other disabilities have been less considered because eye care has been favoured and has had more support from international organizations, especially the Christian Blind Mission (CBM).

The success of eye care in the DR Congo through CBR approaches, known for using the faith-based volunteers for identification and ophthalmic nurses during community screening, has been shown to be effective in the identification and referral of paediatric cataracts. The lesson learnt through this good practice was that maintaining regular identification of activities in the

community and high-quality and accessible paediatric cataract surgery services, can help eliminate the backlog of children who are blind from cataracts. This same approach is doable in the context of hearing.

Therefore, the purpose of this literature review is to examine the role of CBR for early intervention and rehabilitation for children with hearing loss, and how the LEAQ and the AAST as hearing screening tools can be integrated into CBR approaches for early detection of children at risk of hearing loss.

4.3 Objectives and research questions

4.3.1 Objective

To determine the role and effectiveness of the LEAQ and the AAST as hearing screening tools in the CBR programme.

4.3.2 Main research question

To what extent can the LEAQ and AAST be integrated into the CBR programme as hearing screening tools for infant and children in the DRC?

Two sub-questions were formulated

1. What is the role of CBR in promoting ear and hearing health service in the DRC?
2. How effective is the LEAQ and AAST in promoting early detection and diagnosis of children at risk of hearing loss into the CBR programme in the DRC?

This study examined the existing literature for evidence about the role CBR may play in addressing the plight of children with hearing loss. Evidence was sought to answer 2 questions on the role of CBR in promoting ear and hearing health service at community level and on appropriateness of a CBR approach in promoting early detection of children at risk of hearing loss from a multicultural and multilingual perspective.

4.4 Methodology

The study adopted a secondary research design which encompassed collecting data from pre-existing literature and available sources, such as the internet using various search engines. As there was little literature on CBR for children with hearing loss, we embarked on an extensive literature search using keywords like ‘community-based rehabilitation’, ‘hearing loss’, ‘children living with hearing loss’, ‘effectiveness of CBR’, ‘role of CBR’, ‘caregiver role in hearing loss’ and ‘burden of hearing loss’. We utilized the following databases: Google Scholar, PubMed, BMC, the ASHA, HINARI and WHO websites, and many other open access and peer-reviewed international journals. We limited our search in English and French to the most recent literature, no older than 10 years, although we included some important, critical literature that had exceeded the 10-year period since its.

Data were combined and compared for any duplication and later assembled into a usable format. A secondary data design was adopted for this study to enable a review of a broad body of literature on the role of CBR in promoting ear and hearing health service at the community level, and the appropriateness of the CBR approach in promoting early detection of children at risk of hearing loss from a multicultural and multilingual perspective.

4.5 Results

RQ1. What is the role of CBR in promoting ear and hearing health services in the DRC?

In many African countries, CBR at the community level is part of an integrated community development programme that relies on the mobilization and building on local resources in the community (Helander, 2007). The resources include the family of the child with hearing loss, teachers, health workers and the community (WHO, 2010). Unfortunately, in sub-Saharan Africa, there are limited resources and prospects of early identification of hearing loss. For example, the WHO estimates only one audiologist per 0.5 million to 6.25 million people in the developing world with countries in sub-Saharan Africa having a ratio of 1 audiologist per 0.8 million people (Ciorba et al., 2012). Consequently, community-based hearing programmes have been proposed as a way to improve access to ear and hearing care. Table 24 shows the roles specific to ear and hearing healthcare that CBR plays in the rehabilitation of children with hearing loss according to the WHO (2012b).

4.5.1 summary of the literature review: suggested intervention for primary ear and hearing care in to CBR Programemes

Table 24: The role of CBR and early *i*ntervention in relation to hearing loss (WHO, 2012)

Role of CBR	CBR intervention
Advocacy:	Campaigning for ear and hearing health services at all levels of health care.
Facilitation:	Providing access to ear and hearing health care services.
Prevention:	Avoiding causes of hearing loss.
Sensitization:	Creating public awareness in all aspects of hearing loss. Participate in events that will help to raise awareness, such as a 'Healthy Ear and Hearing Day' or a 'Deaf Awareness Week'.
Coordination:	Promotion and provision of accessible communication for those with hearing loss.
Relief:	Necessary attention at times of humanitarian crisis and disaster preparedness.
Capacity building:	Education and training programmes that may lead to employment.
Civic educ.:	Encouraging development of a stronger voice advocating for the rights and development of self-help support groups.
Reintegration:	Encourages society to ensure inclusion of people with hearing loss in social groups and community events.
Guidance:	Guide parents through the process of identification and management of hearing loss and subsequent rehabilitation, as well as raising awareness about the modalities of communication and open education opportunities to persons with hearing loss.
Lobbying:	Promote, organize and participate in events that will help to raise awareness, such as a 'Healthy Ear and Hearing Day' or a 'Deaf Awareness Week', and in fund-raising activities.

Table 25: Summary of the literature review

Source	Method	Country	Suggested activities: integrating primary ear and hearing health into CBR
Olusany et al. (2008)	Cross-sectional study	Nigeria	➢ Training of CHWs on hearing loss screening of infants
McPherson (2012)	Cross-sectional survey	India	➢ Training of CBR workers on hearing loss screening. ➢ Designed low-cost versions specific to physiological hearing screening tests for developing countries
Shouneez et al. (2018)	Cross-sectional study	South Africa	➢ Early childhood development programmes specific to hearing screening using mHealth point-of-care diagnostics and cloud-based data management and referral systems
Cheng-Yu et al. (2007)	Reflection	Taiwan, China	➢ Specific education to parents on hearing loss screening
M'kumbuzi, & Myezwa, H., 2016	Systematic review	South Africa	➢ PWD focusing on children with hearing loss and their families
Amar-Singh (2004)	Cross-sectional survey	Malaysia	➢ Screening test/ instrument designed for hearing loss

Mahmoud et al. (2017)	Cross-sectional study	Egypt	➢ A specific hearing screening programme with correct equipment, trained personnel and adequate follow-up services for accurate diagnosis
Dube (2013)	Case study	India	➢ Development of low-cost hearing screening for infants ➢ Questionnaire screening permanent for young children
Basenez (2015)	Cross-sectional study	Uganda	➢ Prevention programme for hearing loss for primary, secondary and tertiary institutions
Packer & Yau (2011)	Survey study	China	➢ Specific programme addressing change of attitudes, perceptions and beliefs regarding hearing loss
Velem & Cornielje (2010)	Survey study	India	➢ Development of sign language, and use of specific learning material, e.g., finger braille
WHO (2012)	Documentary review	India	➢ Sign language for people with hearing loss
Basavara & Nandurkas (2007)	Exploratory study	India	➢ Establishment of schools for children with hearing loss

Source: CBR and EHC Journal (WHO, 2012) and ASHA, Journal (2017)

RQ2. How effective is the LEAQ and the AAST in promoting early detection and diagnosis of children at risk of hearing loss into the CBR programme in the DRC?

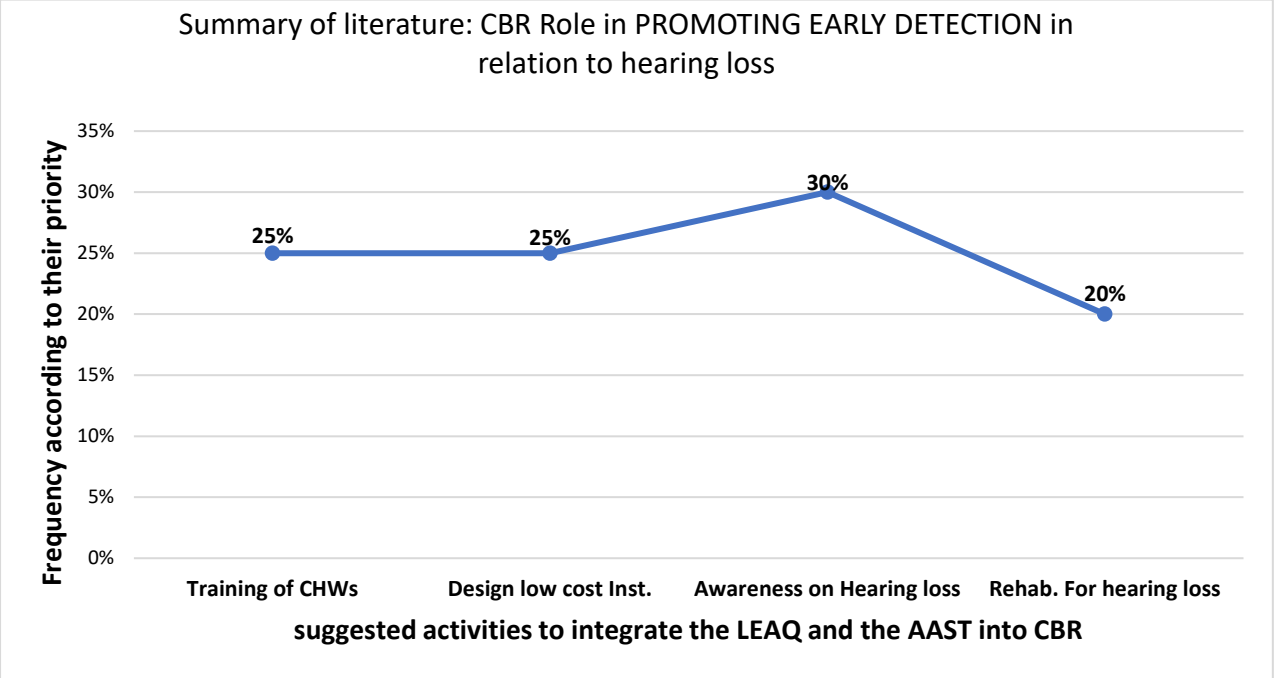


Fig. 40: Summary of the role of CBR in promoting early detection

This figure shows that activities related to community awareness are more legitimized and encouraged, followed by the training of community health workers and the provision of low-cost materials or equipment for early detection and diagnosis.

4.6 Discussion

4.6.1 Integrating the LEAQ and the AAST as screening tools into CBR programmes

4.6.1.1 Community awareness

The general body of knowledge indicates that when children are targeted early enough for screening for hearing loss, especially through their parents, the overall outcome in terms of reduction or elimination of hearing loss, education attainment, speech and language development and participation in society activities, including employment, is generally better (Bush et al., 2017; Maluleke et al., 2019&Yoshinaga-Itano 2017). The target group for hearing screening for children has been based on the most at risk group of children (children with delayed speech-language, children born with birth injuries, birth asphyxiated children) and such approaches have provided better yields for the screening programmes (Wroblewska-Seniuk et al., 2017). In view of the preceding evidence, the burden and public health importance (impact) of hearing loss among children justifies the need for screening for early intervention. These findings are in line with the principles and characteristics of the LEAQ that involves parents (Coninx, 2008). Raising awareness and empowering parents for the use of simple hearing test tools can be a sustainable action. This is also supported by Olusanya et al. (2008) that involving community members and CHWs will enhance the chances of success, and the author demonstrated that it is possible to detect hearing loss early in established primary care centres using CHWs.

4.6.1.2 Designing adapted and low-cost screening tools/instruments

This study was aimed at developing a low-cost screening tool to identify hearing loss in children in the DRC that could be used by community agents and parents of the Family Health Programme in the future. For decades, screening for hearing loss for children varied widely according to context and the resources available, including audiology specialists and other hearing care professionals (Dobrow et al., 2018; WHO 2018; Wroblewska-Seniuk et al., 2017). For neonate and infant screening, OAE and automated auditory brainstem response (AABR) are recommended as non-invasive (test safety and acceptability) and easy to use (simplicity) even by auxiliary staff. They have been validated and found to be objective and reliable screening methods for screening hearing loss (Wroblewska-Seniuk et al., 2017).

These 2 methods have found limited use in less-developed regions like Southeast Asia, the Middle East and sub-Saharan Africa, where over 80% of children living with hearing loss reside (WHO, 2018). This finding agrees with other WHO recommended methods such as family questionnaires and behavioural measures for hearing screening in children, especially in resource-limited settings (WHO, 2010). Some studies have employed mHealth technologies in the initial stage, and children who are later identified as high risk or with probable hearing loss are referred for further professional assessment (Ramkumar et al., 2019). Though OAE and ABR are recommended tests for screening hearing loss because they meet almost all the standard characteristics of screening tests (Wroblewska-Seniuk et al., 2017), the WHO still recommends the use of other test methods for screening hearing loss in children in resource-limited regions or countries (WHO, 2010). The Wilson and Jungner screening test may be recommended if there is no better readily available test, and based on its simpilicity of application (Wilson & Jungner, 1968). Therefore, countries should adopt the test methods that best suit the prevailing healthcare delivery challenge and keep finding ways to adopt OAE and

ABR technology for screening hearing loss. This legitimizes both the LEAQ and the AAST as cross-culturally adapted tools with language-specific, cultural barrier-free, easy to learn and understand and low-cost suitable screening tools that can contribute to improve the community accessibility on ear and hearing health services, whereby in rural areas in the DRC, there are many challenges related to the geographical accessibility (Ofei & Coninx., 2014; McPherson, 2012).

4.6.1.3 Integration of volunteers (CHWs) from local communities and their training

A number of primary studies and systematic reviews have focused on the contribution of CHWs in the delivery of essential health services at the grassroots level. In many countries, a group of informal health workers also provide services on a voluntary basis, either at the health-centre level or through a CBR programme, but there has been no specific studies examining their role and potential contribution in a range of health problems, especially ear and hearing care in the DRC.

Considering the views of Dobrow et al. (2018), the decision makers should consider the programme or system features such as coordination that involves human resources especially at the community level, integration, ethics, acceptability, benefits and harms of screening programmes, as well as economic performance of the screening activity (Dobrow et al., 2018). Major challenges reported by programmes screening for hearing loss in children, especially using community-based approaches, have been referral and follow-up management for cases(Ramkumar et al., 2019; Hussein et al., 2018) simply due to the lack of good programme orientation and integration of CHWs for early indentification.

Some studies have also produced a poor yield of cases. These are typically those programmes that have employed family questionnaires and behavioural methods to screen for hearing loss

in children (Wroblewska-Seniuk et al., 2017) because of lack of good connections and skills needed for CHWs. The findings from this study support the idea of McPherson (2012) that community-based screening needs to be linked to community health activities such as immunization clinics where CHWs, if trained, provide quality services. This supports the idea of an integrated and collaborative approach to carry out hearing screening during home visits. Furthermore, O'Donova et al. (2019) demonstrate that, CHWs have the potential to improve access to ear and hearing services, not only in low-resource countries, but also in remote areas. The current focus should not be to wait for the best test and / or practices for screening hearing loss, but to use what is affordable as efforts are made to move to better screening tests for hearing loss.

4.6.2 Suggested activities and desirable outcomes for the LEAQ and the AAST as screening tools in CBR programmes

4.6.2.1 Parents' involvement for early detection of children at risk of hearing loss

There is wide acceptance that parents can make the greatest difference to children's achievement (Harris and Goodall, 2008). Parental involvement in the use of the LEAQ in early detection for children with hearing loss is necessary and desirable (Moeller, 2000; Sarant et al., 2009). This is supported by Brewer et al. (1989) who describes family-centred care as the focus of the philosophy of care in which the pivotal role of the family is recognized and respected in the lives of children with special health needs. Clearly, within this philosophy is grounded the idea of parental support in their natural care-giving and decision-making roles by building on their unique strengths, and they are seen as equals in a partnership committed to the delivery of all levels of health care.

4.6.2.2 Level of integration: LEAQ and the AAST in PHC in the DRC

Despite the absence of a programme for early detection of hearing loss, as one of the public health problems, the DRC has a good, decentralized health facility in accordance with PHC standards, which is a great opportunity to offer ear and hearing health services to the population through a bottom-up approach

The health centre as the first-level care facility comprises the following services:

1. Community Awareness Unit
2. Preschool Consultation Programme
3. CBR service

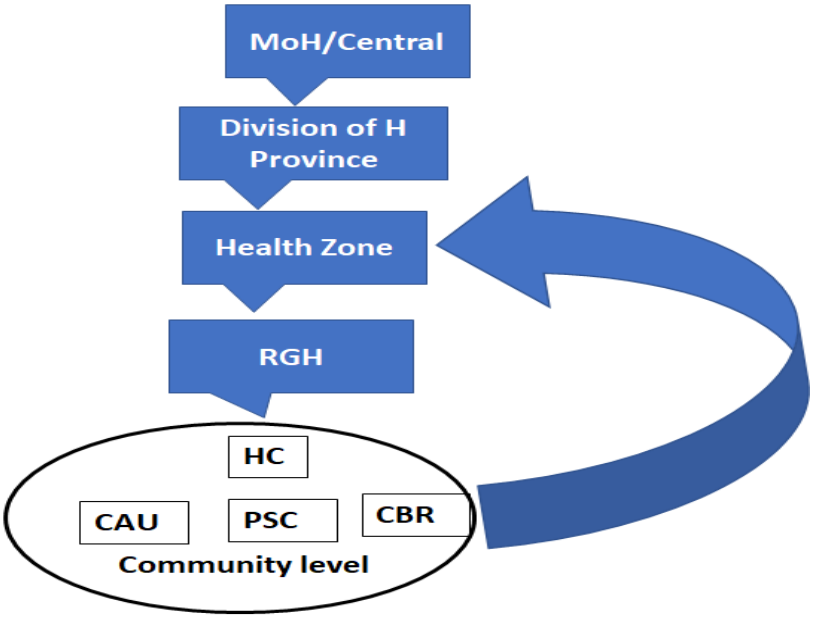


Fig. 41: Interconnection of health services at the PHC level in the DRC

4.6.2.3 Community services and their roles

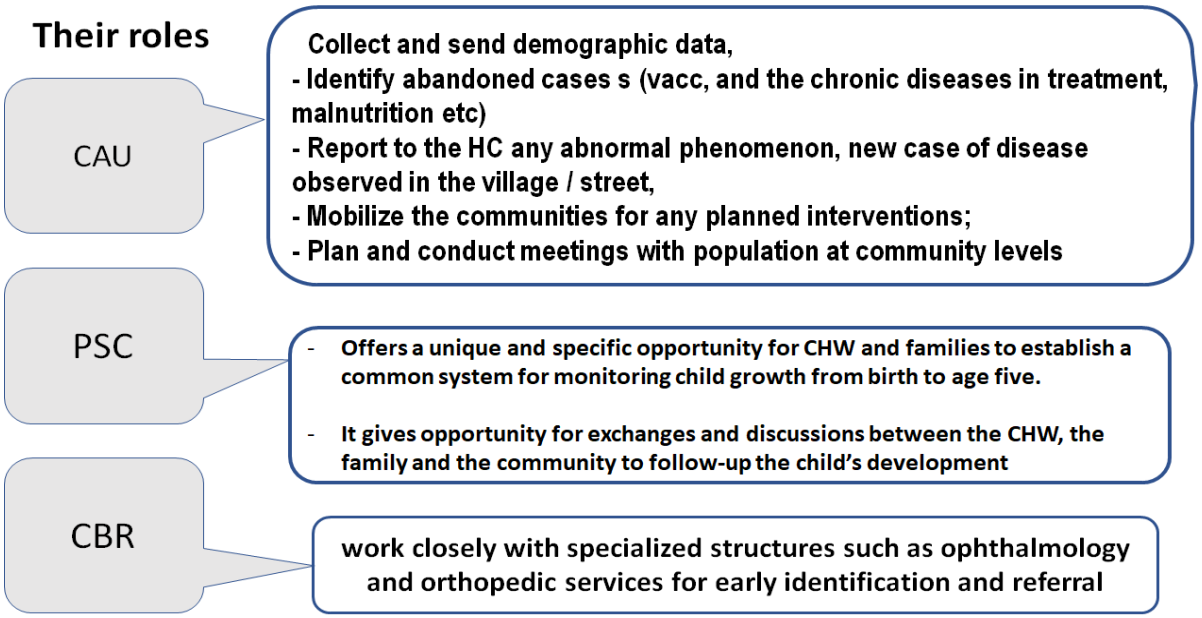


Fig. 42: Community services and their roles

4.6.2.4 Appropriateness of the LEAQ and the AAST into community services as a screening tool

There is a great opportunity that, the LEAQ and the AAST be integrated into services available at community-based level because of their flexible and adaptable characteristics to suit the needs of the population regardless of their social or educational levels (fig 40). describes the

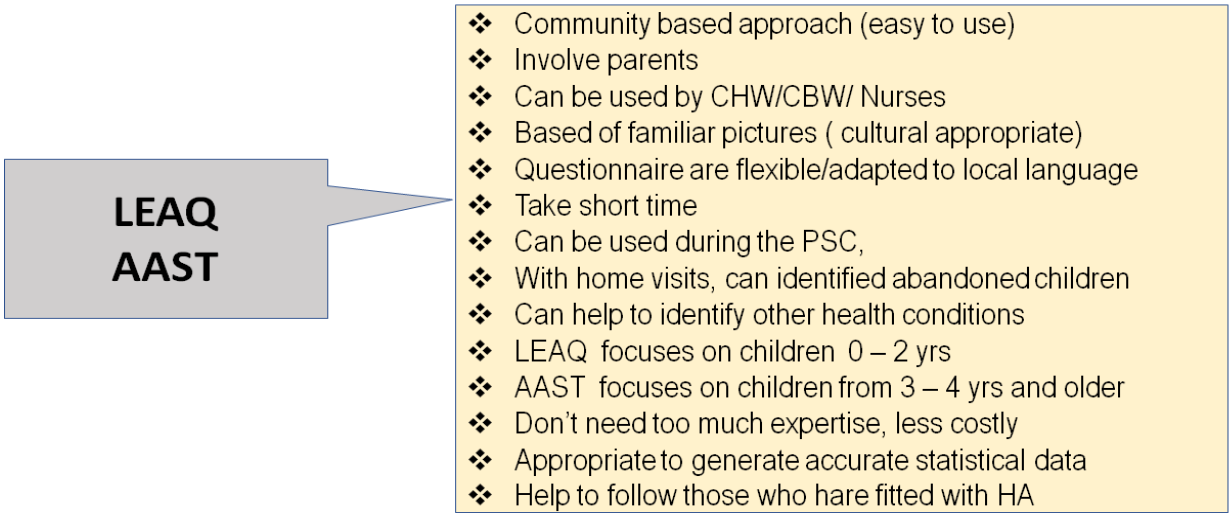


Fig. 43: The LEAQ, AAST and their appropriateness as part of community activities

The Declaration of Alma-Ata recognized the CBR as a key strategy to promote and improve access to rehabilitation services for people in their communities (WHO, 1978). This is supported by Turmusani et al. (2002), who reported that new directions in CBR need to be put in place. Thus, promoting ear and hearing through CBR should maximize its benefit. This is the transfer of basic rehabilitation skills from professionals to PHC workers. In addition, Wade (2003) suggested that rehabilitation is more effective when given in a patient's own environment, and this is in line with the fact that the LEAQ was primarily identified as a reliable tool to be used for hearing screening for children up to 24 months (Coninx, 2008), and the test should involve parents as key persons to monitor the auditory behaviour of the child.

Once more this optimizes the integration of the LEAQ as a structured instrument / questionnaire, it motivates parents and other caregivers to comment on the child's auditory behaviours. More importantly, Nekes (2016) and Offei (2013) reported that the AAST was proved and considered to be a reliable tool for screening children and could be used as a diagnostic tool to determine the SRT. This means that due to its community-based characteristic design, such as pictures and questionnaire, locally adapted and familiar to the child, the AAST, as well as the LEAQ are appropriate tools to be used at community level where there are no other physiological methods.

4.7 Summary and conclusion

4.7.1 Summary

This chapter aims at determining the role and effectiveness of the LEAQ and the AAST as hearing screening tools into the CBR programme.

Over the decades there has been increased adoption by governments, local communities and NGOs in utilizing CBR approaches as a strategy within the general community in addressing the service needs of people living with disabilities. Despite the increase in the use of CBR and its diversity of strategies, as depicted by the WHO (2008) to leverage support and interventions for people living with disabilities, its adoption in the early intervention for children with hearing disabilities has been limited, especially in countries like the DRC.

From the pre-existing literature, the general body of knowledge indicates that community-based hearing programmes have been proposed as a way to improve access to ear and hearing care. When children are targeted early enough for screening for hearing loss, especially

through their parents, the overall outcome in terms of speech and language development is generally better.

This chapter legitimizes the use of the AAST and LEAQ as low-cost screening tools to identify hearing loss in children in the DRC that may be used by community agents, parents of children with hearing loss and health programmes in the future.

In addition, raising awareness and empowering parents and CHWs in the use of AAST and LEAQ test tools can be a sustainable action, and will enhance the chances of success to detect hearing loss early in established primary care centres using CHWs.

Furthermore, integrating both the LEAQ and the AAST as a cross-culturally adapted tools that are language-specific, cultural barrier-free, easy to learn and understand and low-cost suitable screening tools, can contribute to improve the community accessibility on ear and hearing health services, whereby in rural areas in the DRC, there are many challenges related to geographical accessibility.

4.7.2 Conclusion

A major finding from this study is that CHWs with focused training can successfully screen children for hearing loss. This agrees with Mullan (2007) who maintains that non-specialists could play an increasing role in the provision of basic community-oriented hearing health care services and address the shortage of health workers in resource-poor settings. Moreover, the WHO (2004) reports that a high proportion of births in developing countries occur outside hospitals. This suggests that any new child health intervention should be tailored to cater for both hospital and community-based screening to minimize the social and economic burden of

hearing in countries with much higher prevalence rates (Schroeder, 2006). Therefore, voluntary and community services may remedy the situation.

The use of CHWs in the delivery of certain health services to population groups with limited access, like in the DRC, appears promising. However, the success in ear and hearing care requires careful implementation, strong support in awareness raising, provision of the adapted and low-cost instruments, and training of CHWs through a community-based approach.

CHAPTER FIVE: SUMMARY AND CONCLUSION

5.1 Introduction

The WHO resolutions regarding the prevention of deafness and hearing loss have been adopted (2018), which encourages member states to implement screening programmes for early identification of ear diseases and hearing loss in babies and young children. In addition, there are many tests developed and used to diagnose hearing loss and most of these tests have been developed in English, and therefore the adapted versions of them have been developed by several countries in their national languages. However, there is a lack of such a comprehensive programme so far in many middle- and low-income countries, including in the DRC.

5.2 Summary of the strong outcomes of the study

The first part of this study described the conditions of many children in the DRC, who die before the age of 5 due of preventable or treatable diseases. For those that survive, some of these leading causes of death, such as malaria, measles, meningitis, HIV / AIDS, low birth weight, malnutrition, which are also serious risk factors for hearing loss, remain undetected due to lack of hearing screening and diagnostic tools, and also due to the lack of a NBHS in the PHC system, despite some progress in improving the healthcare system.

This study opens up the opportunity to attempt in developing the first hearing screening tool, hoping to result in the reduction of the severity of shortages of audiological services in the DRC, and to provide parents with the right information about the hearing state of their children to allow them to make the right health decisions. Moreover, there is great hope to

integrate the first hearing screening tools into the PHC system as an alternative measure to the UNHS.

The second and the third parts, which were the main content of this study, dealt with the development and adaptation of a hearing behaviour test for children called the LEAQ into 2 national languages: Lingala and Kiswahili, based on a questionnaire that describes hearing development conditions for a normal child. Similarly, the third part focused on the development and adaptation of a hearing test, the AAST, which was also constructed and adapted in Kiswahili, one of the DRC national languages.

Regarding chapter 2, this study examined the correlations between the age dependency norm values of auditory skills for the LEAQ Lingala and Kiswahili versions, which were very similar to the German original version. The study concluded that even when the LEAQ is conducted in different multilingual countries, the test is effective and shows similar results. This is likely to be because it is easy to administer and is also culturally adapted.

In relation to the difference between the auditory behaviours observed by respondents in urban and rural areas, the findings showed that the location of the respondents in these areas, including the lifestyle of the population and whether they are in the low or high classes, does not have much influence on mothers' and caregivers' understanding of the auditory behaviours of their children. The difference between the auditory behaviour observed by respondents who are biological mothers and others such as fathers, siblings, grandmothers, and caregivers were observed, and no relationship was found between categories of respondents and the scores. This means that the status of the respondents of being either the biological mother or not has less effect on the LEAQ scores for both the Lingala and Kiswahili versions.

In order to compare the impact or the effects of education level on the LEAQ scores, the study did not reveal a significant difference in the LEAQ Scores and the education level of respondents, especially in the Lingala region, although there were slight differences, but not statistically significant, for respondents from the Kiswahili region. Those who have a university level of education seem to have better LEAQ scores compared to those with primary and secondary level education.

Regarding the appropriateness of the LEAQ as a community-based screening tool in detecting auditory deficiency in children aged 0–24, a follow-up test with otoscopy and tympanometry at the ENT and Audiology Service for Lingala-speaking children was done and only children with the LEAQ scores below the expected values and aged 6 to 24 months were considered. The findings from this chapter revealed that 28 children (4.5%) out of 618 were screened as having a hearing disorder that included impacted wax, OAE, ear discharge and CP.

Furthermore, children aged 25–36 months were also included in this study, whereby a child of 26 months with bilateral atresia and microtia, who scored 0, and a child of 30 months with severe malnutrition, who scored only 16, were identified. This finding prioritized the LEAQ as a sensitive tool to detect children at risk of hearing loss at this third year of age, especially in an African context where many children in rural areas are confronted with malnutrition and other developmental aspects.

The third part of this thesis dealt with the construction and validation of the AAST test. A six-word, computerized, automatic closed set was developed in Kiswahili in accordance with the criteria initially established for the construction and validation of the first test in German and recommended in other previous languages. The study confirmed that the AAST could be reliable and used as an assessment and diagnostic for screening children in the DRC.

The fourth part of this thesis focused on the role and effectiveness of the LEAQ and the AAST as hearing screening tools that can be integrated into the CBR programme as low-cost screening instruments, though OAE and ABR are the recommended tests for screening hearing loss because they meet almost all the standard characteristics of a screening test (Wroblewska-Seniuk et al., 2017). Besides this, the WHO still recommends the use of other test methods for screening hearing loss in children in resource-limited regions or countries (2010).

This means that countries should adopt the test methods that best suit the prevailing healthcare delivery challenge and keep finding ways to adopt acoustic otoemissions (AOE) and ABR technology for screening hearing loss. This legitimizes both the LEAQ and the AAST as suitable low-cost screening instruments and cross-culturally adapted tools, along with being language-specific, cultural barrier-free, and easy to use, which can contribute to improving community accessibility in ear and hearing health services in urban and rural areas in the DRC.

Community awareness and parents' involvement are key strategies in a CBR programme. Findings in this study are in line with the principles and characteristics of the LEAQ that involves parents (Coninx, 2008). Raising awareness and empowering parents has great implication for the use of the LEAQ and its sustainable action for routine screening at the PHC level.

Regarding the role of community volunteers, findings in this chapter showed that a number of primary studies and systematic reviews have focused on the contribution of CHWs for the delivery of essential health services at the grassroots level, and volunteer involvement has been proved to be a key component of successful CBR projects. This implies the necessity of carrying out hearing screening at community level, as supported by McPherson (2012), that community-based screening needs to be linked to community health activities, such as immunization clinics where CHWs and volunteers, if trained, could be suitable people to use the LEAQ and the AAST to provide quality services.

Regarding the level of integration of the LEAQ and the AAST in PHC , from the pre-existing literature, the general body of knowledge indicates that community-based hearing programmes have been proposed as a way to improve access to ear and hearing care. This study showed that the DRC has a good decentralized health facility in accordance with PHC standards, which is a great opportunity to offer ear and hearing health service to the population through a bottom-up approach, by using the LEAQ and AAST at the health centre, which is the first-level care facility that comprises different services: a Community Awareness Unit, an immunization service, prenatal and preschool consultation services and CBR services.

5.3 Conclusion

This study aimed at developing the first hearing test tool, adapted to national languages, for the early detection of children at risk of hearing loss, and how it can be integrated into the primary health care system in response to the permanent consequences of diseases and factors leading to deafness in the DRCT. Both the LEAQ and the AAST Kiswahili version can be used for the screening and diagnosis of hearing loss in children under and over 3 years old in the DRC, and these instruments will contribute to improving community accessibility in ear and hearing health services in urban and rural areas in the DRC, where there are many challenges related to geographical accessibility. Moreover, the LEAQ should be used routinely to identify infants with mild hearing loss, especially in a country like the DRC where the ENT and audiology services are almost non-existent in rural areas, to minimize any reduction in the quality of language input during the first 2 years. Lastly, the LEAQ and the AAST, as the first screening and diagnostic tools, can be integrated into the CBR programme in the DRC to promote ear and hearing health service, and serve as an alternative measure to the UNHS programme. This will have a positive implication by generating concrete data that will have considerable impact in influencing the legislation and the integration of the LEAQ as a screening tool in the PHC package.

CHAPTER SIX: LIMITATIONS OF THE STUDY, FUTURE RESEARCH AND RECOMMENDATIONS

6.1 Limitations of the study

The study has some unexpected limitations that might affect the findings to some extent. Firstly, due to the scarcity of documentation for phonemes distribution in Kiswahili, this study referred to the phonemes distribution of Ciluba, which is also a Bantu Language and one of the national languages in the DRC, because of their similarities in the spoken and written characteristics. This could result in less accuracy in the consonant and vowels distribution during the construction process of the AAST.

Regarding the sensitivity of the LEAQ, due to the outbreak of coronavirus (COVID-19) from March 2020, the second follow-up after the first screening with the LEAQ was not possible in the Kiswahili-speaking provinces due to the lockdown and the ban on transport. As a result, no data were recorded after the first screening to find the outcomes of the otoscopy and tympanometry tests.

6.2 Future research

1. There is a need to construct and validate the LEAQ in Kikongo and Tshiluba versions, so that the whole country is covered. In the same perspective, the version of Lingala as one of the national languages and Congo French as the official language is of great importance.
2. The construction and adaptation of a 4 words AAST version in Kiswahili, Lingala and Congo French can also be explained in the DRC context in order to minimize the errors that can occur due to short attention span of younger children aged 3-5 years old. A short duration test is in line with guidelines for hearing screening in the school setting that hearing screenings should be done in a short amount of time (Coninx, 2008; Coninx et al., 2009).
3. Assess the level of acceptance of the LEAQ in all 4 national languages in order to provide guidelines for its application in the PHC system as an alternative test to the UNHS.

6.3 Recommendations

A. In the health sector
    1. The LEAQ can be used by CHWs, community links, CBR volunteers and parents, especially during home visits, during immunization activities, or during prenatal or postnatal consultations.
    2. Both the LEAQ and the AAST can be used by social workers during the first visit of a child to a health facility or by nurses or doctors during the first consultation.
B. In the education sector

1. The LEAQ can be used by trained teachers in kindergarten schools.

C. In other social activities such as church services.

1. The LEAQ can be used by a trained Sunday school teacher. Some parents might not have taken their children to kindergarten and may rarely attend health services but can attend church services.
2. The collaboration between the health sector and traditional healers might be of great importance because in rural areas, parents tend to primarily visit traditional healers, especially when they notice a developmental delay in a child. Collaboration and training of traditional healers to use the LEAQ may save hundreds of children at risk of hearing loss at an early age.

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APPENDICES

Appendix 1: The DRC final Version of the AAST Kiswahili

Appendix 2: The Lingala version of the adapted LEAQ

Esika ofandaka...../ Nzela ya singa.....

Motuna etali baboti mpo na koyeba makoki ya koyoka
Motuna etali makoki ya koyoka
Mokolo ya botama ...../...../.....

Kombo ya mwana.....mokolo ya sanza...../...../..... Bomoto :☐ Mwasi ☐ mobali

	Makoki ya koyoka	Eyano	Ndakisa
1	Mwana na yo ayanolaka mpenza mogongo ya bato ya libota?	Ee to te	Asekaka, atalaka epai mongongo ezali kobima (kouta) asololaka na mongongo ya esengo.
2	Mwana nayo ayokaka moto oyo azali kosolola ?	Ee to te	Ayokaka, azelaka koyoka, atalaka molobi na ye tango molayi
3	Tango moto azali kosolola mwana nayo atalaka to abalusaka motó epai ya molobeli na ye?	Ee to te	
4	Mwana nayo amipesaka to asepelaka na biloko ya masano oyo ebimisaka mingongo to miziki?	Ee to te	Na ndakisa: alo alo, bisaleli ya miziki (armonika mpe bongo na bongo)
5	Mwana nayo alukaka amona moto oyo azali sololisa ye?	Ee to te	
6	Mwana nayo ayokaka mpenza na likebi (radiyo, televizio, videyo) soki bafungoli?	Ee to te	Atyaka mpenza likanisi to abalukaka epai mongongo ezali kouta, to azo seka, to koyemba to koloba na tango wana.
7	Mwana nayo andimelaka mongongo ya mosika?	Ee to te	Tango bobengi ye na eteni moko ya ndako.
8	Mwana nayo atikaka kolela soki olobeli ye to opekisi ye, tango aza komona yo te?	Ee to te	Omekaka kobondela ye na mongongo to na loyembo ya mongongo ya nse, ata azali kotala yo te
9	Abangaka soki moto asiliki to atomboki na mongongo makasi?	Ee to te	Ayokaka mawa mpe abanda kolela.
10	Ayebaka kokesenisa biloko to mingongo ya mokolo nyonso ?	Ee to te	Lokola miziki<ee dodo> makelele ya mai, oyo ezali kotsola, makelele ya nsani na tango ya kolya.
11	Atalaka epai nini mongongo ezobimela nzinga nzinga na ye,na loboko ya mwasi to ya mobali, to na sima ?	Ee to te	Soki obengi ye, to soki mbwua egangi, ? pme aluki esika wapi makelele ezali kobima ?
12	Soki obengi mwana nayo na kombo naye, andimaka ?	Ee to te	
13	Atalaka epai nini mongongo to makelele ezali kouta , soki likolo to na nse?	Ee to te	Lokola ngonga oyo etyami na efelo ya ndako ebeti, to tango eloko ekwe na nse.
14	Soki azangi esengo to aza na mawa, atikaka kolela to kosilika tango otyeli ye Nzembo?	Ee to te	
15	Mwana nayo ayokaka mpe ayebaka ete moto azoloba naye na nzela ya singa?	Ee to te	Tango tata mwasi to tata abengi, mwana ayambaka alo-alo mpe ayoki
16	Abinaka miziki na koningisa nzoto, kolanda ndenge ezali kobeta?	Ee to te	Aningisaka maboko to makolo tango azali koyoka miziki.
17	Ayebi kokesenisa mongongo to makelele mpe koloba ezali makelele ya eloko songolo to likambo boye?	Ee to te	Mwana akotala likolo tango ayoki mpepo to ayoki mutuka atali na balabala.
18	Mwana nanyo andimaka kosembolama na mokuse mpe na petee?	Ee to te	Tika!! keba!!
19	Mwana nayo atikaka makambo oyo azali kosala tango opekisi ye koloba < boye te>?	Ee to te	Okoki koloba <boye te> ata mwana amoni yo te.
20	Mwana nanyo ayebi kombo ya bato na ndako?	Ee to te	Wapi tata, mama, Gael, Aramela
21	Mwana nayo alandaka mongongo soki osengi ye yango?	Ee to te	Aaaaa 'oooo' iiiiiiiiii
22	Mwana nayo azalaka na makoki ya kolanda mitinda ya petee?	Ee to te	Yakawa, longola sapato nayo.
23	Mwana nayo asosolaka mituna ya petee?	Ee to te	Lakisa zolo na yo? Wapi tata?
24	Mwana nanyo ayelaka yo biloko oyo osengi ye?	Ee to te	Pesa nga ndembo
25	Mwana nayo amekaka mongongo to maloba nayo ?	Ee to te	Loba wooooof wooof, loba mutuka mbongo na bongo
26	Mwana nayo amekaka mingongo ya biloko ya masano ndenge ezali?	Ee to te	Vruummmm « mutuka » mooo « ngombe »
27	Mwana nayo ayebi mingongo songolo ezali ya banyama songolo ?	Ee to te	Wuu wuu lokola bwa, nyaaaauuu, lokola Nyau,…
28	Mwana nayo amekaka koyekola mingongo to makelele ya nzingnzinga ?	Ee to te	Mingongo ya banyama, ya radiyo, ngonga ebeti,
29	Mwana nayo azongelaka maloba ya mokuse, to ya molayi, soki basengi ye yango ?	Ee to te	La-la-laaaa
30	Mwana nayo ayebi kopona eloko ya malamu kati ya biloko mosusu soki bosengi ye?	Ee to te	Bozo sakana na banyama? osengi ye alakisa punda, to ndembo ya langi ya motane
31	Mwana nayo amekaka koyemba, soki ayoki nzembo moko?	Ee to te	Nzembo na bana
32	Mwana nayo azongelaka maloba soki bosengi ye yango ?	Ee to te	Loba <Mbote> na Tata mwasi
33	Mwana nayo ayokaka esengo, soki ozali kobetela ye lisolo moko boye?	Ee to te	Kouta na Buku moko ya bana to ya bililingi
34	Mwana nayo azali na makoki ya kolanda mitinda ebele ? to mingi?	Ee to te	Longola sapato na yo mpe yaka epai na ngai
35	Ayembaka banzembo oyo libota emeseni koyemba?	Ee to te	Mwana moke abendaka likaya teeeee

Makoki ya kotanga: kelasi yanse ☐ kelasi ya katikati ☐ kelasi ya likolo ☐ kozanga kotanga ☐

2. Ozali nani mpo na mwana : mama moboti ☐ Tata moboti ☐ mosusu ☐ .....

LEAQ Lingala DRCongo, translated from the version

Appendix 3: The Kiswahili version of the adapted LEAQ

Pahali unaishi....., **nambari ya simu**.....

ULIZO YA KUSIKIYA

Ulizo kwa wazazi kwa kutambua hali ya kusikiya.

Jina la mtoto:..... **Tarehe :**...../...../.....

Utupu : Mwanamuke ☐ **Mwanaume** ☐ **Tarehe ya kuzalika :**...../...../.....

	HALI YA KUSIKIYA	JIBU	MFANO
1	Mtoto wako anaweza kujibu akisikia sauti yenye anafahamu ?	Ndiyo /Hapana	Anachekaka ; anangaliyaka kule kwenye kunatoka kelele ; ''anasema'' na hali Nzuri.
2	Mtoto wako anasikiaka mutu kama iko na zungumuza ?	Ndiyo/Hapana	Anasikiaka, anasubiri na anasikia,anaangalia, mutu wakati mrefu .
3	Wakati mutu anaongea, anageuzaka kichwa kuangalia ule mutu ?	Ndiyo/Hapana	
4	Anafurahiaka vitu ya muchezo yenye inatoa sauti ao nyimbo?	Ndiyo/Hapana	Kwa mfano mikebo ao sanduku ya Nyimbo..
5	Anatafutaka kweli mutu mwenye kuongeya kama hamuone?	Ndiyo/Hapana	
6	Mtoto wako anasikilizaka kweli kama radio imewashwa?	Ndiyo/Hapana	Anabakia mukamilifu na anangaliya kwenye kunatoka sauti ama kelele na anacheka ao anaimba.
7	Mtoto wako anaweza kujibu akisikia sauti kutoka mbali ama kuchumba ingine?	Ndiyo/Hapana	Kwa mufano, kama unamuita kutoka pande ingine.
8	Ukimuongelesha akiwa analia, anaweza kunyamaza hata kama hakuona ?	Ndiyo/Hapana	Kama unamubembeleza na sauti nzuri ao na mwimbo nzuri hata hakuone .
9	Anauzikaka wakati anasikia mutu amekasirika ao akiongea na sauti ''kali'' ?	Ndiyo/Hapana	Anakuwa na huzuni na anaanza kuliya .
10	Anajua ao kufahamu kelele ya maisha ya kila siku ?	Ndiyo/Hapana	maji enye inatelemuka, kelele ya mufiniko wakati ya kukula
11	Anaweza kutafuta ao kuangalia ngambo kani kelele iko (kushoto, kuume ao nyuma)?	Ndiyo/Hapana	Ukiita ama kuongea, sauti ya umbwa inawika, ama simu inalia, na anatafuta kuona pahali kelele inatoka
12	Mtoto wako anaikalaka musikivu akisikia jina yake ?	Ndiyo/Hapana	
13	Mtoto wako anaangaliaka kwenye fasi kelele iko ? (juu ama chini)?	Ndiyo/Hapana	Saha kwa ukutani; kitu yenye kuanguka chini.
14	Wakati anahuzuni, ao kama hajisikii vizuri, anaweza kunyamaza kama anasikia Nyimbo nzuri ?	Ndiyo/Hapana	
15	Mtoto wako anasikiaka kwa simu na kujua kama kuna mutu anongeya naye?	Ndiyo/Hapana	Kama Mama Koko anaita, ao Baba, mutoto anakamata na ''kusikia'
16	Mtoto wako anachezaka muziki ama nyimbo na kutingiza mwili?	Ndiyo/Hapana	Kutingiza mukono /na miguu kama anasikiliza Nyimbo.
17	Mtoto wako anaweza kutofautisha sauti ama kelele nakusema hii ni kelele ya kitu ao mambo fulani?	Ndiyo/Hapana	Mtoto anasikia sauti ya Ndege (avio), na anangalia juu, ama sauti ya Gari, na anaangalia barabara.
18	Mtoto wako anajibia sawa kwa maulizo mafupi ao raisi?	Ndiyo/Hapana	''Acha'',Heee ''Hapana''?
19	Mtoto wako anasikiaka ukisema << hapana>> na kuacha kitu ambayo anafanya ?	Ndiyo/Hapana	Unasema ''hapana'', hata mutoto hakuone.
20	Mtoto wako anajua majina ya watu wa jamaa ?	Ndiyo/Hapana	Baba iko wapi, mama, Gaeli, Armeli,.....
21	Mtoto wako anaiga kweli sauti kama una muambia kuifanya?	Ndiyo/Hapana	"Aaa," oooo" ,iii"
22	Mtoto wako anaweza kufwata kanuni ao maelekezo raisi?	Ndiyo/Hapana	''Kuja hapa'', ''tosha viatu''.
23	Mtoto wako anafahamu maulizo raisi?	Ndiyo/Hapana	''Pua yako iko wapi, Baba iko wapi''? ''''?
24	Mtoto wako analetaka kweli kitu yenye unamuomba?	Ndiyo/Hapana	''Leta mupira''...
25	Mtoto wako anaiga kweli sauti ao jina yenye ukimwambia?	Ndiyo/Hapana	Sema "ouaf ouaf" sema ''gari''
26	Mtoto wako akiwa na chombo ama kitu ya muchezo, anaweza iga sauti yake muzuri ?	Ndiyo/Hapana	Kwa mfano :Vroom gari, = tchouf gari la moshi
27	Mtoto wako anajua kweli kama sauti fulani niya nyama fulani ?	Ndiyo/Hapana	Kwa mfano : ouaf ouaf <mbwa>, nyaauu <paka>, jogoo.....
28	Mtoto wako anajaribu kuiga kelele ya mazingira ?	Ndiyo/Hapana	Kwa mfano: sauti ya nyama, kelele ya vinanda , filimbi....
29	Mtoto wako anarudilia kweli masemi fupi ao ndefu kama ukimwambia kuifanya ?	Ndiyo/Hapana	''La-la –laaaa''
30	Mtoto wako anaweza kuchagua kweli kitu sawa katikati ya ingine kama unamuomba ?	Ndiyo/Hapana	Ukiwa unacheza na picha za nyama fulani, na unamuuliza ''Punda''ama mupira ya rangi mwekunda''.
31	Mtoto wako anajaribu kuimba peke yake kama anasikia wimbo Fulani ?	Ndiyo/Hapana	Kwa mfano: Nyimbo ya kuchunga watoto.
32	Mtoto wako anaweza rudilia masemo wakati wanamuomba afanye ?	Ndiyo/Hapana	Sema, ''jambo'' kwa mama koko.
33	Mtoto wako anasikiaka vizuri kama unamwambia historia ndogo ?	Ndiyo/Hapana	Kutoka ndani ya kitabu ya masomo kwa mutoto ao vitabu ya sanamu yenye taswuira.
34	Mtoto wako anaweza kufuata maelokezo ya ngufu ao mengi?	Ndiyo/Hapana	"Tosha viatu yako, na kuja kuniona".
35	Mtoto wako anaimbaka kweli nyimbo zenye wanazoea kwa kijamii?	Ndiyo/Hapana	Ndugu Yakobo.....

1. **Elimu ya masomo: Primari** ☐ **sekondari** ☐ **masomo ya juu** ☐ **bila elimu** ☐

2. **Wewe ni nani kwa mtoto : mama mzazi** ☐ **baba mzazi** ☐ **mwengine** ☐ .....

LEAQ Kiswahili DRCongo , translated from the English version

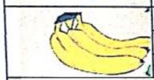
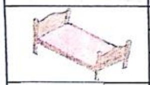
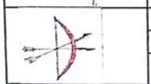
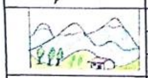
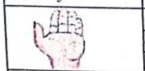
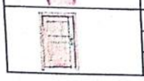
Appendix 4: The data collection sheets format for construction of the AAST Kiswahili version

UNIVERSITY OF COLOGNE
FACULTY OF HUMAN SCIENCES
SPECIAL EDUCATION AND REHABILITATION SCIENCES

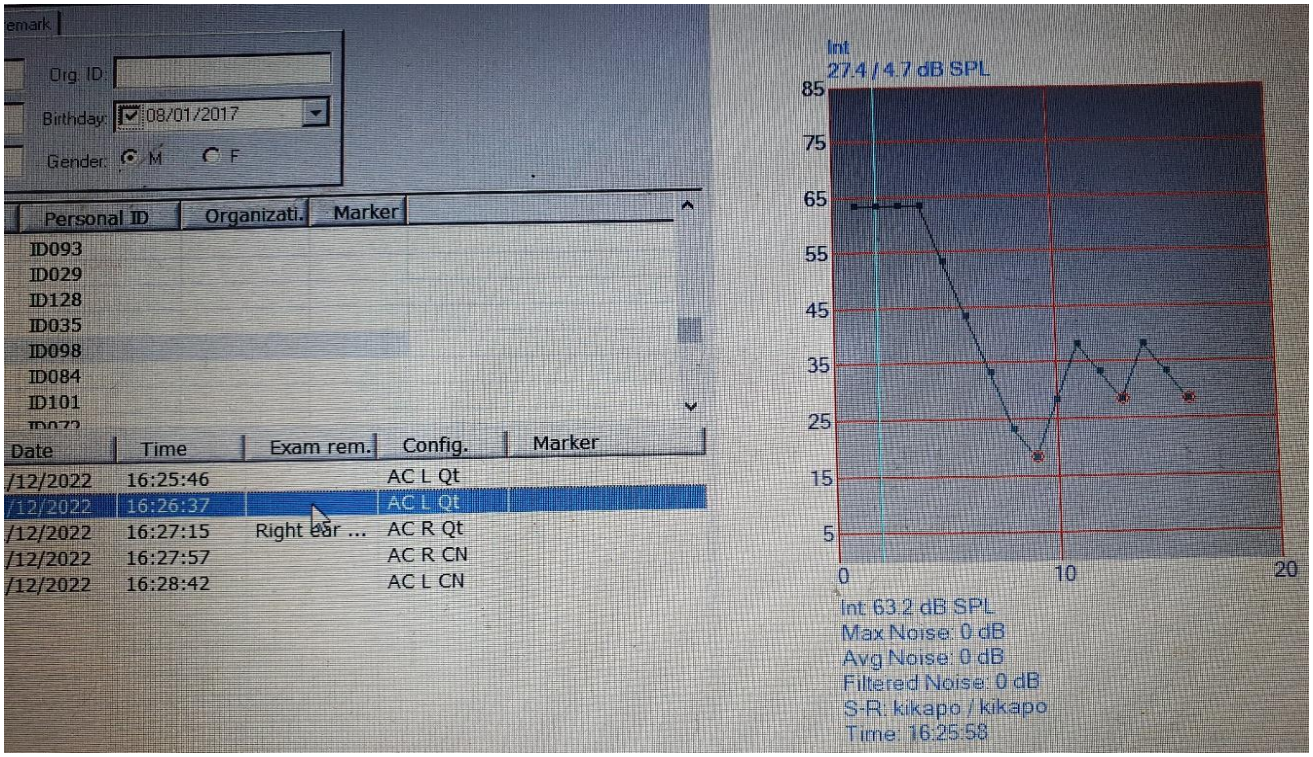
Fiche de récolte de données/ Data collection sheet

Nom de Chercheur / Researcher's name:____________________, Assisté par / Assisted by :__________
Pays:/ Country:____________, Province / Province:____________,
Lieu de récolte des données / Location of data collection:__________________, Catégorie de participants / Category of participants:________________, Tranche d'âge / Age range : ________________,
Nombre de sexe féminin / Number of females:________, Nombre de personnes avec de problème visuel / Number of people with visual problems _________, Autres informations nécessaires / Other necessary information________________________
Langue /Language______**SWAHILI**__________

Instructions: noter sur une échelle de 1 à 3, rate on a scale of 1-3. ***(1) = Parfaitement reconnu/ Perfectly recognized (2) reconnu avec hésitation /Recognized with hesitation (3) non reconnu/ Unrecognized***

Image (S1-30)	Echelle/ rate	nombre de comptage/nummber of tallying	Total (n)	Total (N 30)	%
	1				
	2				
	3				
	1				
	2				
	3				
	1				
	2				
	3				
	1				
	2				
	3				
	1				
	2				
	3				
	1				
	2				
	3				
	1				
	2				
	3				
	1				
	2				
	3				
	1				
	2				
	3				
	1				
	2				
	3				
	1				
	2				
	3				

Appendixe 5 A 4 years child stable emotionally but with impacted wax on the left ear



Appendix 6: a child of 7 years full of fear of the headphones during the AAST Test